OCT 13 1910

JOURNAL OF ELECTRICITY

POWER AND GAS

Devoted to the Conversion, Transmission and Distribution of Energy

Entered as second-class matter May 7, 1906, at the Post Office at San Francisco, Cal., under the Act of Congress March 3, 1879

VOL. XXV NO. 15 | SAN FRANCISCO, OCTOBER 8, 1910 | PER COPY, 10 CENTS

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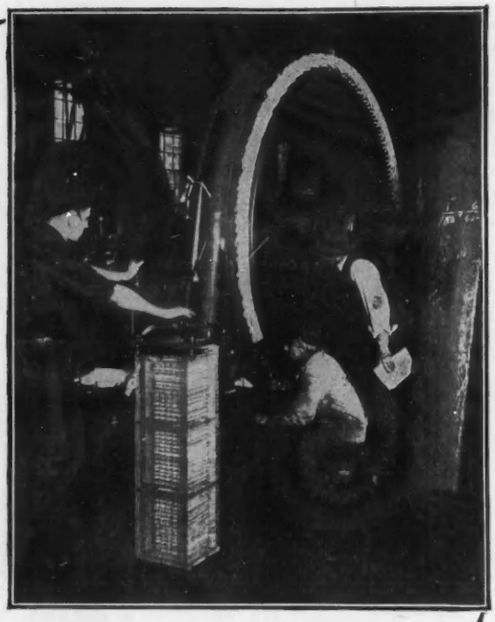

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VOLUME XXV SAN FRANCISCO, OCTOBER 8, 1910. NUMBER 15

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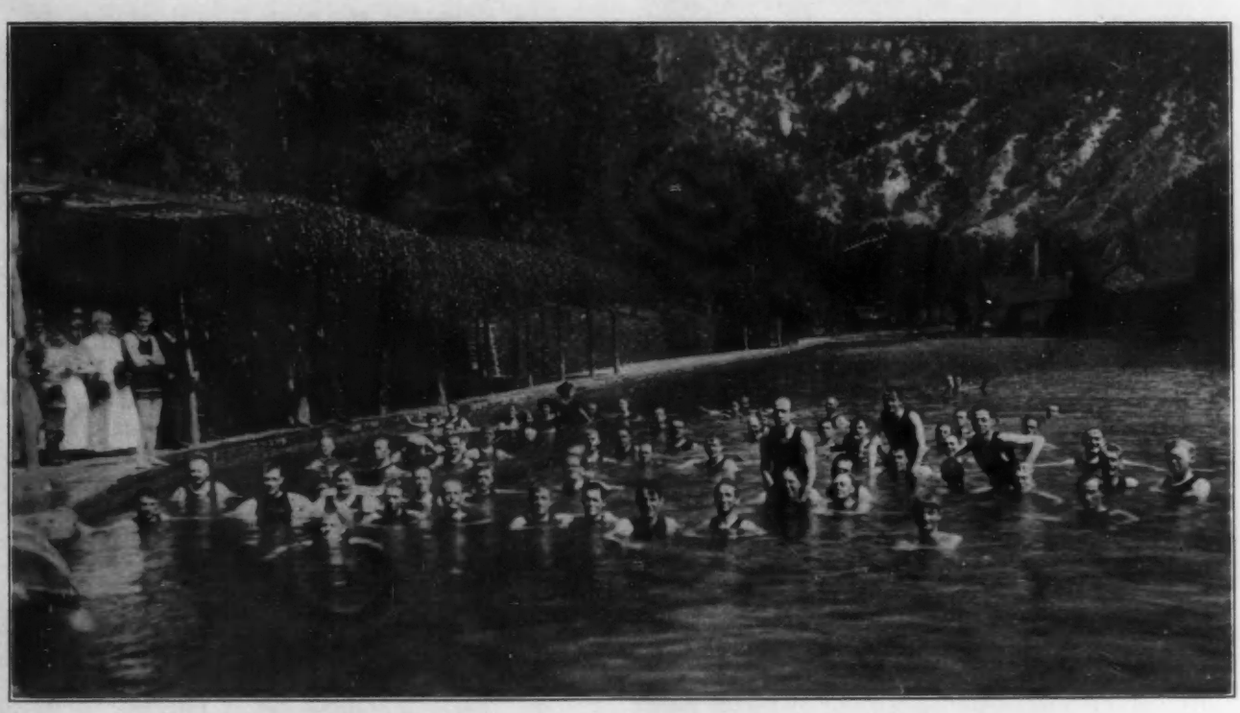
STEAM TURBINES[1]

BY E. M. GILBERT.

In a brief paper of this description, it is not the intention to enter into a mathematical discussion of the theory of turbines, nor yet to compare different types and makes, but merely to give a few general details, considering these machines as a separate and distinct class of prime movers.



Clean Sport of the Colorado Electric Light, Power and Railway Association at Glenwood Springs, Colorado.

The field has been covered so completely in the many books and magazine articles published during the last few years, that one cannot hope to present anything new. As, however, this subject had never been taken up before the local society it was thought that a brief discussion of types, elementary theory, etc., might be of interest.

It is an interesting historical fact that the principles to which the turbines of today owe their classifications as belonging either to the "impulse type" or "reaction type" were discovered and exemplified by models or small machines many centuries before being put into practical use. This fact justifies a brief mention of these inventions.

Authentic record gives Hero the credit of designing the first turbine, placing the date at about 120 B. C. His design was based on the principle of reaction and was somewhat similar to the small revolving sprinklers so frequently used today for watering lawns, except, of course, that it used steam instead of water.

Nothing further is heard of steam turbines until the seventeenth century, when Branca invented an impulse machine. This merely consisted of a simple turbine wheel, against the buckets or blades of which steam was blown. The study of engineering at the

[1]Paper read before the Colorado Electric Light, Power and Railway Association at its eighth annual convention, at Glenwood Springs, Colo., September 21, 22, 23, 1910.

time of these discoveries had not been developed enough to enable use to be made of the inventions, so that they have no practical value except to illustrate the simplicity and age of the basic principles upon which all turbine construction is more or less dependent.

It was understood long before the practical use of turbines was demonstrated that the high peripheral velocity of simple turbines was a great obstacle, which must be overcome either by reduction through gears or some such appliance, or by a change in design of the machine itself. In the early part of the nineteenth century two Frenchmen invented a turbine, attempting to gain speed reduction by distributing the drop in pressure through several stages. This without doubt was the forerunner of the multistage machine so popular today. In 1883 De Laval took out a patent on a reaction type turbine, closely following the original design of Hero, and six years later another one (now known as De Laval turbine) using the Branca design, made practical by many improved features of the utmost importance. About this time Parsons also brought out his first machine, which is classed as belonging to the reaction type, although strictly speaking it seems to employ a combination of both principles.

Curtis in 1896 patented his machine, which, while using many of the essential features of De Laval's invention, applied them in such a way as to make practicable larger machines and slower speeds than those possible with the former design. The development of the turbine industry has been very rapid since the last date given, many of the machines produced being merely modifications of the three mentioned. In fact, the De Laval, Parsons and Curtis turbines may safely be taken as representative of types under which all machines are classified, i. e., single stage impulse type, reaction type, multistage impulse type.

The following gives the classification of a few well known turbines:

Impulse Type	De Laval		Single Stage
	Curtiss	Nozzles for Expansion	Multi Stage
	Kerr		
	Rateau		
	Hamilton-Holzworth		
Reaction Type	Parsons		
	Westinghouse-Parsons		
	Allis-Chalmers		

A brief examination into the theory of the turbines, without going into the question of thermodynamics will help to an understanding of the action of the different types of machines.

Steam under pressure possesses potential energy but has no motion unless allowed to expand. By expansion this potential energy may be changed into kinetic energy, or velocity, this energy being expended in overcoming the resistance of the air or whatever opposes the increase in volume of the steam. The energy developed depends almost entirely upon the number of expansions and not upon the pressure at which these expansions take place, i. e., as much energy is released in expanding steam from 2 lb. to 1 lb. pressure as between 150 lb. and 75 lb. pressure.

The energy of a moving jet of steam is expressed in terms of its weight and velocity by the following formula: $E = \frac{W V^2}{2g}$

It is therefore seen that the velocity is the prime factor to be considered, provided, of course, that a properly designed machine can be made to utilize the energy so obtained.

If V_1 represents the initial velocity of the steam as it impinges on a turbine bucket and V_2 its absolute velocity at outflow, the energy given to the turbine wheel would be per pound of steam, $\frac{V_1^2 - V_2^2}{2g}$, and the impulse efficiency of the machine would be $\frac{V_1^2 - V_2^2}{V_1^2}$

Consider a pound of steam having a velocity of 2000 feet per second as represented by a perfectly elastic ball, and the bucket of a turbine wheel, having a peripheral velocity of 1000 feet per second as represented by a moving plane, much larger than the ball and moving in the same direction, with its plane surface at right angles to the direction of motion. Neglect all frictional losses. The velocity of the ball relative to the plane will then be 1000 feet per second. When it overtakes the plane it will rebound with a velocity relative to the plane of 1000 feet per second. But as the plane still continues at about its initial speed, being much larger than the ball, this means that the absolute velocity of the ball, i. e., its velocity relative to the earth, is zero, so the kinetic energy is 0, all that it had having been given to the plane. This means that the impulse efficiency as represented by the formulae $\frac{V_1^2 - V_2^2}{V_1^2}$ is 100 per cent, as V_2 is 0. In other words, to obtain the best efficiency the bucket speed should be nearly equal to one-half of the initial steam velocity.

The initial velocity of the steam is almost entirely dependent upon the design of the nozzle. With a plane orifice a velocity of about 1500 feet per second is possible, with steam at 150 lb. pressure on one side and 2 lb. absolute pressure on the other. This velocity is almost independent of the ratio of the two pressures, provided this ratio is as low as 58 per cent. In other words, where in a multistage machine a drop in pressure of less than 42 per cent is only required, a plane orifice might be used. With a well designed nozzle, such as is used on the De Laval turbine, a velocity between these same pressures of 4010 feet per second is obtained.

In actual practice it has not been found practicable to obtain a bucket velocity of one-half the steam velocity, partially because the nozzles have to be placed at various angles to the buckets, and partly because of other constructional difficulties.

Consider the elementary theory of a De Laval turbine as representing the single stage impulse type of wheel, Fig 1.

Let the crescents represent the cross-section of the blades of the turbine and V_1 be the initial velocity of the steam, Y the bucket speed, and a the angle

of the nozzles to the plane of the bucket wheel. Then the resultant of V_1 and Y is N, which represents the relative entrance velocity of the steam. Neglecting losses the steam would leave the bucket at the same speed, represented by v_2, and by the above method of resolving the forces the absolute velocity would be V_2. Energy developed $= \frac{V_1^2 - V_2^2}{V_1^2}$

The blades of the wheel should be curved so that v_1 is tangential to it, and so prevent any sudden shock

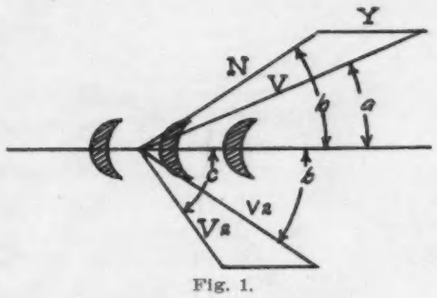


Fig. 1.

due to change in direction of the steam. The exit angle (b), is generally made to agree with the entrance. A consideration of the frictional losses would change the relationship and value of the forces of the above diagram slightly.

The De Laval turbine as representing the single stage machine consists primarily of the nozzle or nozzles in which the steam is expanded to exhaust pressure in one step. This steam is blown directly onto a single wheel to which it imparts a percentage of its energy, from which in turn it is conveyed to the driven apparatus. The nozzle is of the best design, and after passing the smallest section diverges toward the exit, so as to allow for increased volume of steam due to expansion, and so as to use this energy of expansion in increasing the velocity of the steam in the direction of flow. Otherwise this energy would be dissipated in all directions while expanding. For the same reason the discharge end of the nozzle is placed closely against the wheel. Even in the little space allowed, eddy currents are set up which reduce the efficiency. This nozzle is generally set at about 20 degrees with the plane of the turbine wheel and at the side of the same. The nozzles can generally be opened or closed by hand, and the number of nozzles varies with the conditions of operation and power requirements. The wheel itself consists of a solid disc on the periphery of which are mounted the blades or buckets. These latter are crescent shaped in cross-section and are set in milled grooves on the wheel and calked into place. They do not require changing for variations in pressure, vacuum, or superheat, but the nozzles are designed for the conditions of operation and vary in number and size with the above mentioned steam characteristics.

The wheel is mounted on a flexible shaft which allows it to rotate about its gravity center instead of being forced to keep its geometric center.

A fly ball governor actuating a throttle valve through a system of levers is used for regulation. Owing to the small diameter of the wheels used in this type of turbine, the peripheral velocity required, which for maximum efficiency must approach one-half of entire steam velocity, means a very high rotative speed. This varies with different machines from 8000 to 30,000 r.p.m. It is obvious from this that, as before stated, some means of reducing this speed must be used in practical applications of the turbine. In the De Laval machine, gears of very small pitch and specially designed and accurately cut teeth are used. The makers claim that with their gear which gives a reduction of about 10 to 1, there is a loss of only from 2 to 3 per cent when the machine is in good condition.

Now let us consider other methods by which the rotative speed may be reduced to a workable point.

1. The diameter of the wheel might be increased so as to get the required peripheral velocity without excessive rotative speed.

2. The steam might be partially expanded in a set of nozzles and the energy absorbed by a turbine wheel, after which it might be expanded to a still lower pressure and again used, etc., this process being repeated as many times as required. Obviously as $E = MV^2$ a reduction of the velocity by one-half would mean that only one-fourth of the energy would be developed, or in other words, a four-stage machine would be required to reduce the rotative speed 50 per cent, and the reduction is proportional to the square root of the number of stages.

3. A bucket wheel might be designed so as to absorb only part of the energy developed in the nozzle, and then a second wheel placed so as to absorb a second portion, etc. In this way the reduction in speed would be proportional to the number of wheels. The multi stage impulse machine employs one or more of these methods of reduction in order to obtain large power machines with moderate shaft speed.

The simple theory of a turbine is shown in Fig. 2.

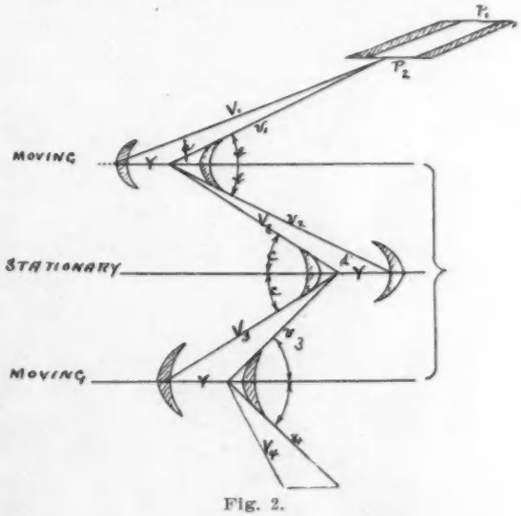


Fig. 2.

Steam is expanded in nozzle N from pressure P_1 to pressure P_2, this latter pressure being determined by the number of stages which the machine is to have, and obtains an initial velocity V_1, while Y represents the velocity of a turbine blade or bucket. The resultant of V_1 and Y or v_1 is the velocity of the steam relative to the bucket and b is the correct entrance angle for the bucket to prevent a shock when the steam enters the same. Neglecting losses and making the exit angle equal to the entrance angle v_2 (exit velocity) $= v_1$. The resultant of this with Y gives the absolute

exit velocity v_2. As the second row of buckets is merely used for redirecting the steam and is stationary the correct entrance angle would be c and not d. In the same way V_2 is taken as equal to V and the resultant v_3 gives the correct entrance angle for the second set of moving buckets.

$$\frac{V_1^2 - V_2^2}{V_1^2}$$

$$\text{Energy absorbed per lb. of steam} = \frac{V_1^2 - V_2^2}{2g}$$

In any one stage the volume of the steam is supposed to remain the same, but as its velocity is reduced during its passage through the stage, the space between the blades must increase. This is generally done by increasing the length and decreasing the thickness of the blades while keeping the pitch constant.

As a general rule all kinetic energy generated by the first set of nozzles is supposed to be absorbed by the bucket wheels in that stage. If, however, the steam leaving the last wheel still has absolute velocity, this will be converted into heat by the impact due to its being brought to rest by the diaphragm between the two stages.

In the Curtis turbine, after passing through the first stage as above described, the steam is again caused to expand through another set of nozzles into a second chamber, called the second stage, where the same process of absorbing the kinetic energy generated in the nozzles is carried on. The nozzles, space between blades, etc., of course have to be larger than those of the first stage so as to accommodate the increased volume of the steam. In some machines this expansion is carried on through a third and fourth stage. Fig. 4 gives a clear view of the steam end of a Curtis turbine as representing the multistage impulse type.

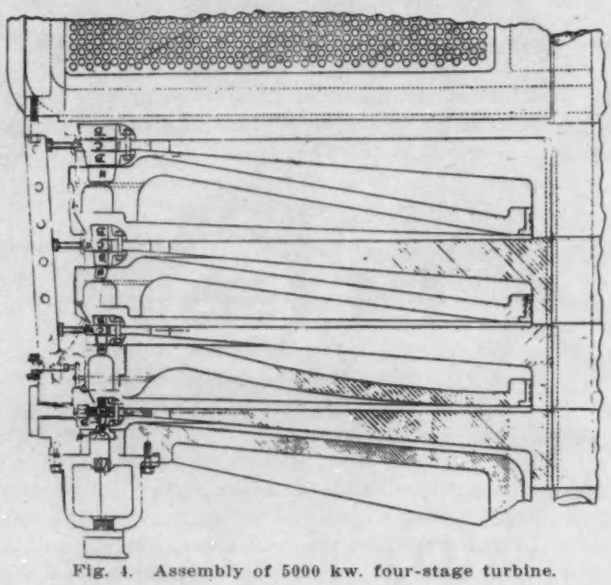
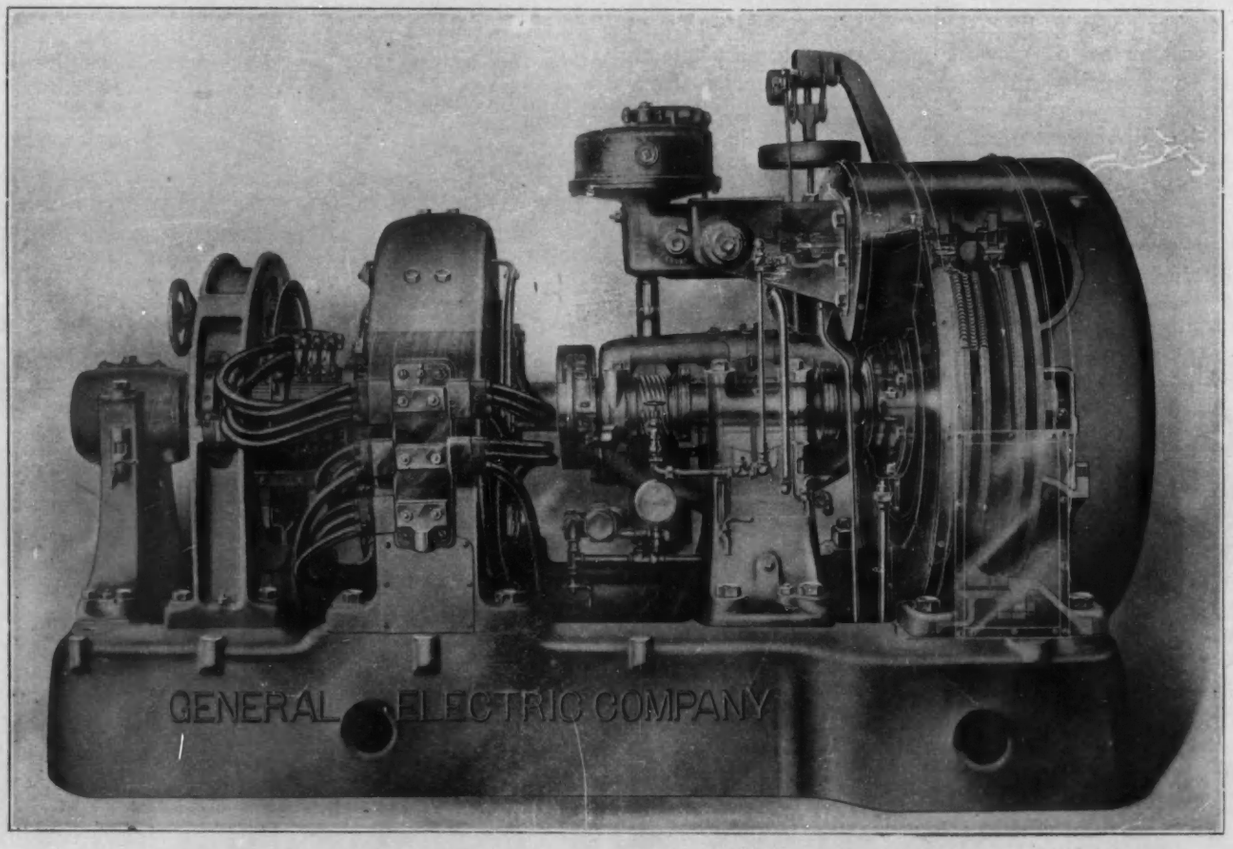


Fig. 4. Assembly of 5000 kw. four-stage turbine.

This cut shows only the steam end. The vertical machine has the generator directly above the steam end, both the revolving field of the generator and the revolving buckets of the steam turbine being on the same shaft. The turbine being vertical, the thrust and weight of the machine is taken by the lower or step



Phantom View of Curtis Steam Turbine.

bearing. This bearing is in two parts, and through the lower one oil is forced at a high pressure. This causes the parts to separate and allows the oil to flow out between them, so that the whole weight of the machine is carried on a film of oil. In some cases water is used in place of oil. The cut plainly shows the increase in size of the nozzles N and buckets B; this allows for the increased volume of steam due to its expansion. It will be noted that one revolving wheel carries two revolving buckets. These are milled in bronze or steel and bolted to the outer edge of the wheel, one on each side, and so arranged that the stationary buckets, C, which are bolted to the outside casing of the machine comes between them.

The nozzles are rectangular in shape and at their large or inner end are only separated by very thin partitions, so that the steam enters in practically a continuous belt. The admission valves are controlled by a governor and are so arranged as to open successively. There is one valve for each nozzle and they may be operated mechanically, direct from the governor, electrically through contacts and solonoids operated by the governor, or hydraulically, by an oil cylinder controlled by the governor. In each succeeding stage the number and size of the nozzles is increased to allow for increased steam volume, until, in a four stage machine they extend, in the last stage, all around the circumference of the wheel. Except in the first stage there is no nozzle control, those in the other stages being open all the time. Carbon packing rings are used around the shaft at each end of the steam cylinder so as to prevent leakage.

The Curtis machines are also built in a horizontal form. The small machines have been built this way for a long time, and during the last year the design of the larger ones has been carried out. These, I understand, are of higher speed than the older vertical machines, and the economy obtained is claimed to be considerably greater than anything previously given by any turbine.

With this machine the axial clearances require close adjustment, but the radial clearances may be large.

In a so-called reaction type of machine, of which the Westinghouse-Parsons and Allis-Chalmers are the best known in this district, the flow of steam is continuous from the inlet to the exhaust. In the impulse machine of the compound or multistage type, as exemplified by the Curtis turbine, the various expansions required take place in nozzles, each stage of the machine being separated so that the bucket wheels rotate in a chamber containing steam at a constant density. In the reaction type—all of which are multistage—no nozzles as such are used, the expansion being effected in the moving and stationary buckets of the machine. The rotor in these machines consists of a large barrel, to the outside edge of which is attached the turbine blades. The stator is of cast iron and to its inside surface is fastened the stationary blades, so arranged as to alternate with the moving blades. The whole expansion takes place in the annular space between the stator and rotor, which in reality resembles a divergent nozzle, this space and also the blades being increased in size toward the exhaust end so as to allow for the increased volume of steam due to expansion. Each pair of blades (1 moving and 1 stationary) is called a stage, and in large machines as many as 100 stages are some times employed. This, of course, means a low velocity of steam, as the expansion in each case is slight. In fact, it varies from 150 feet per sec. at high pressure end to from 600 to 800 ft. per sec. at the low pressure end.

The action, briefly, is as follows: Steam enters the first set of stationary blades and is expanded somewhat. With the resulting velocity it impinges on the moving bucket and imparts energy to the same. On leaving this moving bucket the steam is again expanded and thus has a reactive effect on the bucket, in addition to the impulse imparted by the entering steam. This action is continued until the steam reaches exhaust pressure.

The elementary theory is as follows, Fig. 5, the same notation being used as previously.

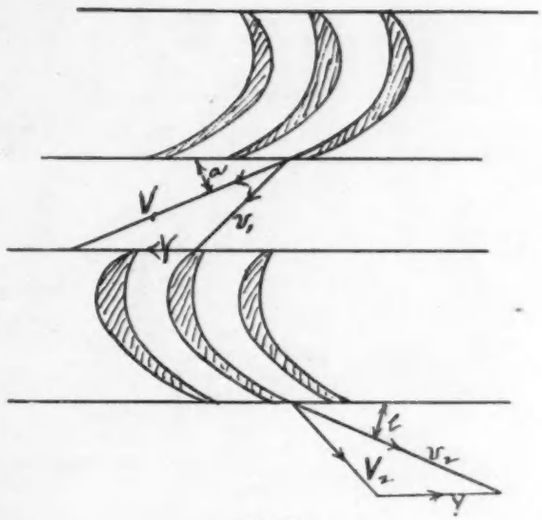


Fig. 5.

Steam receives an initial velocity, V_1 from expansions in the stationary vanes or buckets, which gives a relative velocity, v_1 as resultant of V_1 and Y and shows the correct entrance angle to moving buckets. In passing through the moving buckets the steam is still further expanded and leaves the same with a relative velocity v_2 which is greater than v_1 and which resolved with its component Y gives V_2 as absolute velocity.

The energy developed in the stationary blade for one pound of steam is $\frac{V_1^2}{2g}$. That in the moving blade (without expansion here v_2 would equal v_1) is $\frac{V_2^2 - v_1^2}{2g}$; so the total for one stage would be $\frac{V_1^2 + v_2^2 - v_1^2}{2g}$, while for the total energy absorbed we would have $\frac{V_1^2 + v_2^2 - v_1^2 - V_2^2}{2g}$, and so on through all the various stages.

The accompanying cut of a Westinghouse-Parsons turbine shows clearly the construction of the machine This is given to illustrate a reaction type of turbine. Other machines of this type, while different in their method of construction and in their general details,

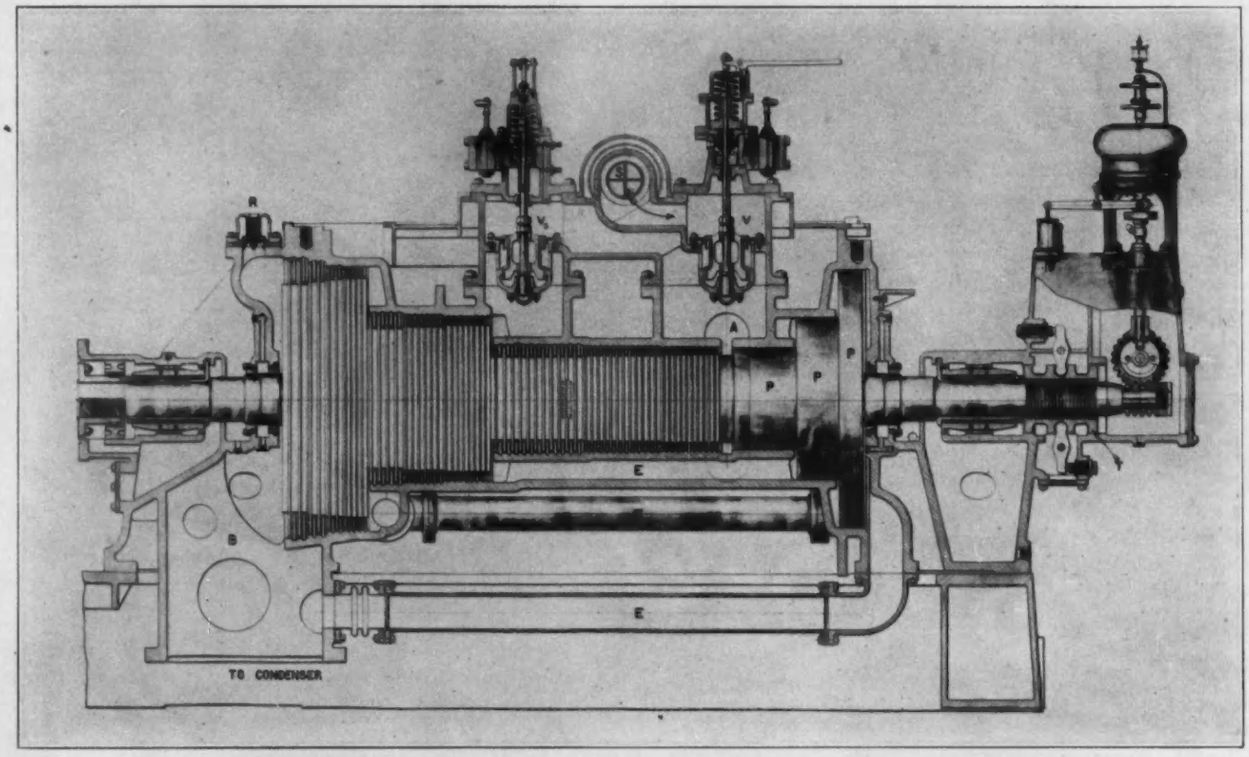
employ the steam in practically the same manner. Briefly, steam enters the turbine through the valves V, which are operated by a small pilot valve, which is in turn controlled by the governor. The valves are of the poppet variety and the steam is admitted in puffs, the amount being determined by the length of time the valve stays open. The steam enters the annular space between rotor and stator at A, and is finally discharged from this space into B. The balance pistons P are each of such diameter as to exactly balance by means of the passages E, the axial thrust of the steam against its corresponding drum or blades.

In the illustration the increase in blade surface to allow for increased steam volume is clearly shown. The varying diameters of the drum or rotor are for the same purpose, and are merely mechanical conveniences. Provision for this increased volume might be made with the drum all of one diameter, but with high pressures, the blades at the entrance end would be very small and at the exit end very large. By varying the diameter, the blades are kept at a convenient size and the number of sizes of blades reduced considerably. In this machine water glands are provided at each end of the shaft so as to prevent leakage. Radial clearances should be small, but axial clearances do not require such close adjustment.

Double flow turbines are now being produced by manufacturers of the reaction machines. In these machines the steam flows both ways from the center, the rotor being in reality of such a shape as would obtain if two rotors similar to those in the illustration were placed with their small ends together. This style of construction does away with the balancing pistons. I am informed that the Westinghouse people are about to bring out a small turbine. This, however, is an impulse wheel, and so not of the same design as their large machines. In fact, I believe that the reaction type of machine has not been found suitable for small powers.

The advantages of turbines as compared with reciprocating engines may be enumerated roughly as follows:

1. Reduction in space occupied and smaller foundations.
2. Saving in oil.
3. Absence of oil in condensed steam.
4. Less vibration.
5. Regulation.
6. Simplicity.



Longitudinal Section of a Typical Westinghouse-Parsons Steam Turbine.

7. Less drop in economy due to age and inefficiency of operators.
8. Economy, especially with load fluctuating heavily.

Let us now consider these points separately and briefly.

1. Consider the smaller units, such as are generally met with in this district, i. e., from 500 to 3000 kw. capacity. At Leadville there is a 1500 kw. Curtis turbine unit set on concrete foundations. This requires 101 sq. ft. of floor space and its foundations contain 25 cu. yds. of concrete. The Denver Gas & Electric Company have in their West Side stations two Filer-Stovell cross compound Corliss stations driven units, the same capacity, each of which occupy 682 sq. ft. floor space and have 153 cubic yards of concrete in their foundations. The three-cylinder vertical compound engines of the New York Edison type probably give the best space economy of any type large

reciprocating unit made, but these occupy about twice the area of a horizontal turbine and from 60 to 70 per cent more than a vertical turbine. The smaller weight and absence of vibration with turbines means a greater possible reduction in the cost and size of foundations when compared with engines than is denoted by the mere relative space economies. The financial benefit of this space economy is readily seen. Consider a 4500 kw. plant containing three 1500 kw. units and using the figures above given from actual conditions. The floor space required for a turbine plant would be 1743 sq. ft. less than for engines, assuming the same amount of free space and the same area for auxiliaries and boilers. An average brick or concrete power plant of this size costs, roughly, from 12 to 14 cents per cu. ft. With a one-story plant about 30 ft. in height the above saving in space means a reduction of $6798 in building cost. The saving in foundations at $10.00 per cu. yd. would amount to $3,840.00 for the three machines. In addition to this we must add 12 per cent for saving in depreciation, interest, taxes and insurance, which give a grand total of $11,914, due entirely to the space economy given by turbine units.

2 and 3. Saving in oil, etc.: There being no internal lubrication and many less bearings requiring oil than on a reciprocating plant, this saving is considerable. The absence of oil in steam means that all condensed steam can be returned direct to the boilers, which means a large saving in many plants, not only in fuel, but in boiler and economizer cleaning, etc., and this without fears regarding the bagging of tubes, cleanliness of oil filters, etc. Mr. H. G. Stott, who is better able to speak on these matters than most engineers, gives the saving due to lubrication alone as being in the ratio of 1.77 for the reciprocating engine to .35 for the turbine, or about 80 per cent.

4. Less Vibration: As explained under No. 1, this factor affects materially the size and cost of foundations, even when the same material is used. Another factor must be considered in this relation also, i. e., this point allows the use of other and cheaper materials for foundations. Some years ago in a Leadville plant it was necessary to increase the capacity quickly. A 500 kw. Curtis turbine was purchased in Denver and shipped to Leadville, where it was set temporarily on a foundation built entirely of 12-inch x 12-inch timbers bolted together, so as to raise the base of the turbine about 8 feet from the basement floor. The bottom of this wooden foundation rested directly on the floor, which was not altered. In this condition the turbine was put in operation until a larger unit should be received and erected. That machine is still running today as originally set up, and at 1800 r.p.m. it is possible to balance a dollar on the edge of the turbine casing.

In many modern installations the foundations consist of steel beams with concrete arches between and resting directly on the floor, the basement below the turbine being used for condenser, etc., instead of being occupied by heavy concrete foundations, thus still further increasing the space economy.

5. Regulation: Reciprocating engines have to be provided with heavy fly wheels to reduce the variations in each revolution, due to lack of uniformity in angular effort. The turbine with purely rotative motion has a uniform angular velocity and an exact regulation is obtained. In fact, most turbines show only from 1 to 2 per cent variation from no load to 50 per cent overload.

6. Simplicity: There are, it is true, many more parts in a large turbine than in an engine, but by far the greater number of these—the buckets—are all used to form one moving part—the rotor—so that the turbine as a whole is much the simpler of the two. It has far fewer moving parts, and this with the absence of stuffing boxes, etc., lends much to the simplicity of operation and maintenance.

7. One point in favor of turbines that is often overlooked is their fixed economy. The turbine economy is established by the design to a great extent. For instance, with given steam conditions, the nozzles, staging, blading, etc., are designed for certain results, which are in no way dependent on adjustment after the machine is turned out. Regarding wear, it seems as though this would only affect the efficiency when it causes a change in the clearance spaces as affecting steam leakage or when changing the shape of the blades or buckets. Among the first designs some slight wear took place in the latter, but in later designs this has been practically overcome, especially where dry or superheated steam is used. Prof. Carpenter reports testing a machine that showed absolutely no difference in economy after three years' continuous usage, and this has been found the case with other machines even after much longer usage.

Reciprocating engines, especially in the smaller types, show rapidly increasing losses due to wear, and in all sizes the economy is due to adjustment. Engine economy should be maintained, but in most small plants and in some larger ones, the engines, as long as they run, are rarely examined or tested, and are often running way below their best economy—eccentrics slip, packing becomes loose and leaky, adjustment becomes bad, valves worn and leaky, alignment poor, etc., and heavy losses ensue, all from lack of attention. The turbine having simple rotative effort and being of fixed designed economy is not subject to these troubles, and surely this is an immense advantage.

8. The economy of a prime mover depends but partly on the pounds of fuel per h.p. hr. The cost of maintenance and operation must also be considered, and this it seems is decidedly in favor of the turbine, partly due to its simplicity and the absence of losses due to adjustment and partly due to saving in packing, oil, waste, etc. For some time it was acknowledged that the steam engine was more economical in fuel consumption under its best conditions of operation than the steam turbine, but during the last year or so this condition has gradually changed until, if anything, the palm lies with the turbine. It is hard to get test results for comparison without making some theoretical correction necessary to get exactly similar conditions. The best turbine results seem to compare favorably with those obtained by the best engines when under test, while in actual practice, when test conditions often do not exist, the turbines come far closer to keeping their economy than do the engines, as above explained. Another

point in favor of the turbine in this connection is the flatness of the economy curve from half load to a large overload. On the accompanying curve sheet, Fig. 6, are stated the results of two tests, one on a 5000 kw. Curtis turbine and one on a 5000 kw. four-cylinder compound engine in the plant of the New York Interborough Metropolitan Company (A. I. E.

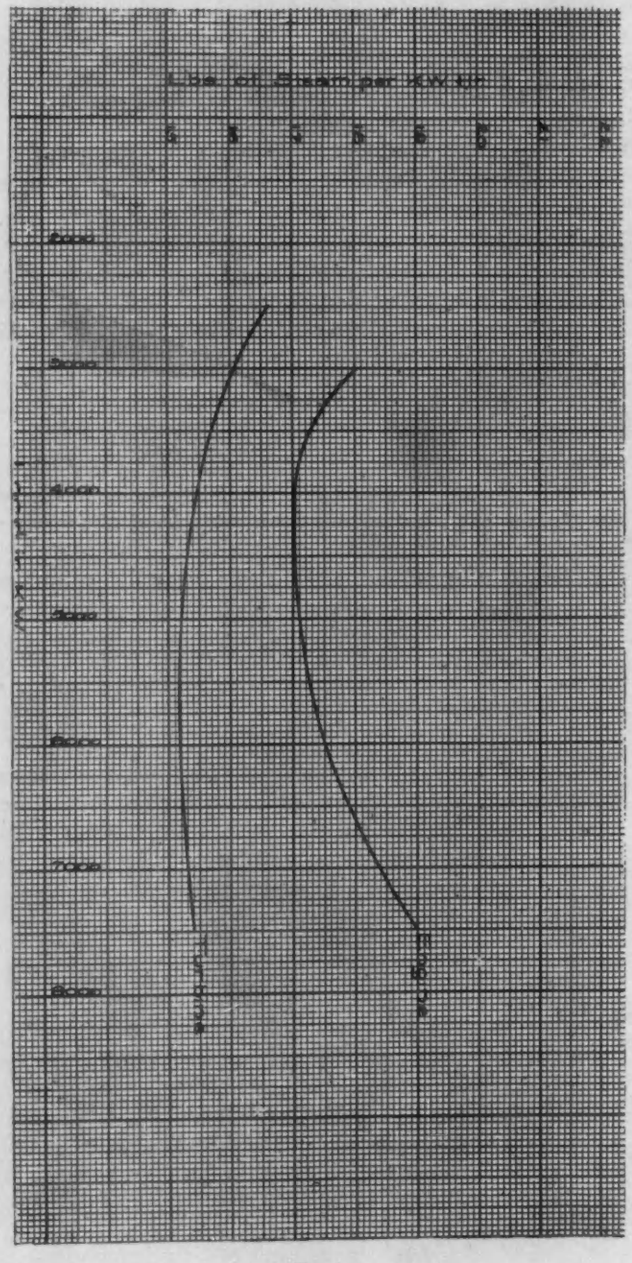


Fig. 6.

E. 1906.) Both are reduced to the same working conditions. While the turbine shows marked advantage in the steam consumption at all points, this is especially apparent at both ends of the curve. In other words, it is necessary with an engine to operate within 20 per cent of rated load if economy is expected, while with a turbine this variation can extend safely from one-half load to 75 per cent overload. In electrical work or any other class of plant where variable loads are expected, this fact gives an immense advantage to the turbine. This not only effects an economy, but increases the peak capacity very materially.

The cost of turbines as compared with engines is hard to give, owing to the difference in the ratings employed. I have obtained at various times figures on plant cost, which may be interesting, however.

The following bids were made on a contract requiring several 100 h.p. and 150 h.p. high speed units. The bids include the auxiliaries:

Curtis turbines	$17,360
De Laval turbines	17,000
Terry turbines	17,985
Skinner engines	21,478
Harrisburg engines	24,000

This seems to show that with small turbines and engines the cost of the latter is from 20 to 35 per cent higher than the former.

The curves in Fig. 7 show the cost of various high speed engines as compared with those of a Kerr turbine. These figures were given me by the various agents and should be correct. This shows that above 150 h.p. the turbine prices are very attractive when compared with those of the better class engines and that they become more and more so as the size of the unit increases. Some prices which I have on larger turbine units show a cost of:

$20.00	per kw.	for	500	kw.	unit.
$17.00	"	"	1,000	"	"
$15.50	"	"	4,000	"	"

Superheated steam is coming into greater use each year in connection with reciprocating engines. In this country more than 200 to 250 degrees F. of superheat is rarely used, but in Europe the temperatures are higher. It is a question whether these highest temperatures pay. The actual reduction in steam consumption may be offset by maintenance, cost of operation, etc.

With high pressures and high superheats considerable difficulty in maintaining the superheater is experienced. To the cost of this maintenance must be added the cost of the fuel required to give the extra heat to the steam, and any extra expense from trouble with the prime mover due to the use of this steam. Sometimes difficulty is experienced with cylinder lubrication, warped valves and unequal expansion due to high steam temperatures. The principal gain from this source with reciprocating engines is caused by the partial elimination of cylinder condensation due to the heat above the saturation point and also to the lower conductivity of superheated steam. With a turbine, there being but little cylinder condensation, the principal gains from superheating are from the reduction in windage or wheel friction, and in the steam friction. Of course this is in addition to the energy obtained from the extra heat of the steam, while there being no interior lubrication or valves, the difficulties above mentioned in connection with reciprocating engines are not experienced with turbines.

A gain of one per cent in the steam economy of a high speed reciprocating engine is obtained for each ten to twenty degrees increase in superheat, while turbines give the same increase in economy on about twelve degrees increase in superheat.

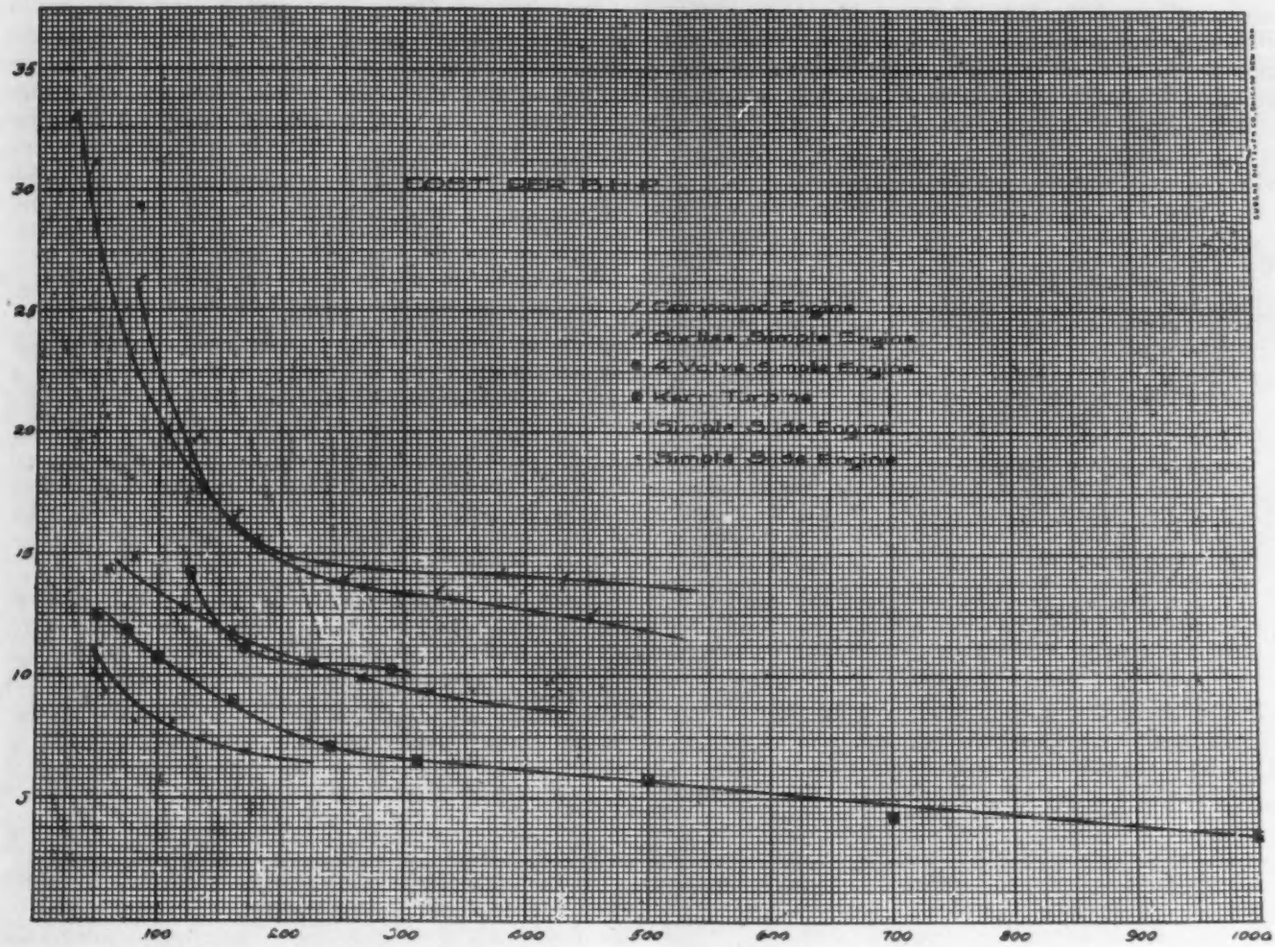


Fig. 7

Most engines show a rapidly decreasing gain per inch of vacuum above 22 or 23-inch (30-inch barometer), and what gain there is is due principally to a decrease in back pressure. Turbines, on the contrary, continue to show substantial gains up to the practical limit of vacuum. It is sometimes argued that the first cost and cost of maintenance of condensing apparatus capable of giving the high vacuums used by turbines offsets the gains.

There is, without doubt, a considerable increase in this first cost, but it can by no means offset a gain on consumption of 3 to 5 per cent per inch of vacuum which is obtained by the turbine. Many turbines are now built to set directly on top of the condenser, or at least so that there are very short connections between, so reducing the leakage possibilities to a minimum. There is even then, however, more necessity for tight joints and good operation than with a reciprocating unit, as any failure in this line with a turbine means much greater loss, at low back pressures especially, than it would with a reciprocating unit.

One branch of the turbine industry that is being pushed very heavily at present, is the building of non-condensing machines especially adapted to high speed work with moderate powers, such as the driving of high pressure blowers, centrifugal pumps, and small generators. The small space, and the simplicity, together with reliability of operation and small cost of maintenance, is fast giving a big demand for these machines. Those that have obtained the most prominence are the machines manufactured by the

De Laval Steam Turbine Co.,
General Electric Co.,
Terry Steam Turbine Co.,
Kerr Turbine Co.,

although several other makes are in the market.

The De Laval and Curtis machines have been briefly described.

The Terry turbine is what might be called a single stage impulse machine with multiple bucket extraction. The steam is expanded through a nozzle and after acting on the wheel is re-directed through 180 degrees and again acts on the wheel, this process being repeated until all velocity or energy has been extracted.

The Kerr turbine is becoming well known in the West and gradually coming into more general use. This machine is of the multistage impulse type, with several velocity extractions, but only one per stage. The nozzles are converging and blow the steam onto buckets similar to the Pelton water wheel bucket.

While I have referred to these small machines as non-condensing, they are also used with condensers and give under those conditions largely increased economy.

Low Pressure Turbines.

One of the reasons for the slow economical development of the steam engine during the last few years, has been the inability of finding practical means to adjust this machine to properly utilize to the full extent the energy possessed by steam at pressures well below the atmospheric line.

A pound of dry steam expanded adiabatically from 155 lb. absolute pressure to 15 lb. absolute gives up in work about 176 B.t.u., while between 15 absolute and 1 lb. absolute 170 B.t.u. would be released, and during the whole expansion the volume of steam has increased roughly 124 times; while if this steam were expanded to ½ lb. absolute pressure its volume would be again nearly doubled. In fact, 1 pound of steam would occupy at ½ lb. absolute pressure about 640 cu. ft. of space.

The amount of energy obtainable from a pound of steam depends on the number of expansions possible in the apparatus using it, and cylinders and valve openings of sufficient size to accommodate the rapid increase in volume at very low pressures cannot be profitably used. Even if a machine of this kind were designed and built so as to allow of expansion of the steam to ½ lb. absolute, there would be no economy gained. The cylinder condensation would increase so rapidly that it would probably more than offset any gain due to expansion. In fact, most condensing engines open to exhaust at about 6 lb. absolute pressure. It has been proven conclusively by tests that there is but very little gain with a reciprocating engine due to an increase in vacuum above 22 inches (30 inches barometer) and that a maximum is practically reached at 26 inches. A low pressure turbine, however, overcomes these difficulties. It can be built with areas in nozzles or between blades sufficient to accommodate the large volume required at very low pressures. There is no dropping off in the increase of economy caused by a corresponding increase in vacuum, even to the very lowest pressure, as with a well lagged casing, cylinder condensation is practically absent. Another point in favor of the low pressure turbine is the fact that the windage or frictional losses are less with low pressure steam than with high, due to the decreased density of steam.

Briefly, there is practically as much energy in a pound of steam at 150 lb. absolute below the atmosphereic line as above it, but the reciprocating engine cannot use it to advantage, while the turbine built for the purpose can.

A condensing engine rarely shows more than from 25 to 30 per cent gain over a non-condensing condition, and even less where the engine is overloaded. An exhaust turbine used in connection with a non-condensing engine will give an increased output of 50 per cent over that which could be obtained by changing the engine from non-condensing to condensing, or from 75 to 100 per cent over non-condensing conditions.

The low pressure turbine can be advantageously applied to any plant where reciprocating engines are used, either condensing or non-condensing, and by showing a decidedly increased economy naturally largely increases the peak capacity of the plant without any alteration in the size of boiler plant.

A large number of plants with reciprocating engines are run non-condensing, due to the low cost of coal obtainable or to the absence of a good supply of condensing water. This is certainly justifiable where the interest on first cost of condensing apparatus, etc., plus the cost of maintenance, is such as to offset the saving due to condensing. There are, however, very few, if any, cases where this condition could exist when compared with the saving given by an exhaust turbine.

About ten years ago one of the large plants of Colorado found that their capacity was too limited to meet their demands. The plants under their control and which fed into common mains, consisted of a hydroelectric plant of 2250 kw. capacity, a small steam plant of about 1000 kw. and a larger steam plant of 2250 kw. rated capacity. Owing to location, quantity of water available, etc., it was not deemed advisable to alter either of the first two mentioned plants, but it was decided to make all additions to the main or 2250 kw. steam plant.

The equipment here consisted of three 1000 h.p. Corliss engines, each direct connected to a 750 kw. generator and run non-condensing, so that the logical manner of increasing the peak capacity was by the installation of an exhaust turbine between the engine and a new condenser. This was done; a Westinghouse low pressure turbine of 1500 kw. capacity being installed and a cooling tower with pond being built. This turbine was supposed to take the exhaust from the two engines, but it was found that owing to overload capacity it could utilize economically even more than this. The following figures give the really startling results obtained:

When the engines were first installed careful tests were made on them, the best results obtained being 32 lb. of steam per kw. hr. Later, the chief engineer of the plant made some very careful adjustments and thinks the steam consumption was decreased to about 31 lb. per kw. hr. Compare this with the results obtained on a careful test made later under ordinary running conditions on two of the engines running in conjunction with the Westinghouse turbine, and which gave the following results:

Duration of test	8 hours
Kw. hrs. generated	16,730
Average steam pressure	150 gauge
Average vacuum	21.6 inches
Average back pressure (exhaust main)	3 lbs.
Dry steam per kw. hr.	17.67 lbs.

I do not know what percentage of this load was given by the turbine, but judge from the results obtained that it would be approximately 70 per cent of that from the two engines, while the mere installation of a condenser alone would have merely given an increase of about 25 per cent. The actual monthly running cost for generation only, before and after the turbine installation, is also instructive. In making this comparison, periods of time have been chosen during which practically the same rate of generation was being carried on, so that a very fair measure of the success obtained is given. For September, November and December, 1908, (before the turbine was in-

stalled) the monthly kw. output agrees very closely with that of January, February and December of 1909, (after the installation), and so these months are compared in the following table. On most of the other months of 1909 the generation at this steam plant was low, owing to their being an abundance of water for use at the hydro plant.

Month.....	Sept. '08	Oct., '08	Nov. '08	Jan. '09	Feb. '09	Oct. '09
Total kw.-hr	1,441;710	1,388,940	1,445,560	1,577,280	1,417,670	1,421,430
			Cost per kw.-hour.			
Fuel,	$.004650	$.004780	$.005200	$.0034650	$.0032780	$.0030600
Boiler Room Labor,	.000930	.000850	.000960	.0007025	.0007600	.0004850
Engine Room Labor,	.000407	.000381	.000408	.0004267	.0004690	.0004830
Water,	.000140	.000144	.000155	.0001436	.0001567	.0001609
Oil, Waste, etc.,	.000029	.000098	.000100	.0001001	.0000930	.0000836
Repairs, Steam,	.000309	.000363	.000289	.0003190	.0001962	.0000879
Repairs, Electrical,	.000012	.000028	.000052	.0000084	.0000107	.0001408
General Labor and Repairs,	.000013	.000027	.000391	.0001781	.0000743	.0002300
Sundry Expenses and Supplies,	.000127	.000102	.000088	.0001001	.0002832	
Condensing Apparatus Repairs,				.0000430	.0000158	.0000000
Total,	.006637	006673	007643	0054865	00534	00474

I am assured by those in charge of this plant that the month of December more closely represents their generation costs than do those of January and February, 1909, as the last two named months were the first two of operation with the turbine and were before the best method of operation had been decided upon.

In comparison there is one point to be mentioned, i. e., the condensing apparatus is electrically operated, and while this table gives the actual cost of producing a kw. hr. (the current used for condensing being in the total) it would be best in studying the result to remember that the cost of this condensing apparatus current would add about 3-10 mills to the figures given.

It will be seen that there is a practical reduction in nearly every item which goes to make up the table given. Owing to the addition of the extra machinery it might be thought that the cost of maintenance would be materially increased. This, however, is not the case —in fact, the total average monthly expense for maintenance of steam apparatus has decreased since this turbine was added. This is probably due to the decrease in load on the old machines, which were previously overloaded, and to the fact that enough capacity is now installed to enable the plant to be overhauled occasionally and kept in better shape.

In the plant just discussed an induction heater is placed between the engines and the turbine and by this means the feed water is kept nearly as hot as before and apparently with little loss to the turbine. This was advisable owing to the condenser apparatus being electrically driven. The exhaust pipe between engines and turbine is generally kept at about ½ lb. above atmosphere. This is good practice, as it prevents leakage of air into the pipe. Although the turbine is provided with a governor, this is not used, but the regulation is carried by the engines, the turbine merely using the steam given to it.

Lately this same company have installed an Allis-Chalmers turbine of 1500 kw. capacity, so arranged that it can be run condensing direct or can be used with the exhaust turbine. This latter machine has also done well. In an eight-hour test run, under ordinary daily conditions with about 20-in. vacuum, and with a load varying from 820 kw. to 2370 kw., or from about one-half load to nearly 70 per cent overload, a steam consumption of about 21 lb. of steam per kw. hr. was obtained. This fact again emphasizes the importance of steam turbines over reciprocating engines where a very variable load is carried.

There is another field for this machine that should be mentioned, i. e., in plants using reciprocating engines intermittently, such as rolling mills, hoisting plants, etc. In cases like this a steam regenerator receives the exhaust from the engines and supplies it to the low pressure turbine. This device absorbs the steam in excess of that required by the turbine and then gives it up again automatically when there is a deficiency from the reciprocating engines.

Mixed pressure machines are now built to accomplish the same result. These are connected to both the exhaust supply and to the live steam main. In case of the exhaust failing a special governor admits live steam direct to the machine as long as required. This steam acts on the same bucket wheel as does the exhaust, being, in the Curtis machine for instance, expanded down to the same pressure as that of exhaust steam, and so obtaining a high velocity and being capable of giving up much more energy than if it were supplied at first stage pressure through a reducing valve or some such device. These mixed pressure machines can be operated to their full capacity on either all low-pressure steam; all high pressure steam, or on any proportions of each, and any transition from one to the other condition is automatic.

In conclusion, it is interesting to note the position taken by the Engineering News regarding the future of the turbines. This journal frankly states that these machines have reached a point where they seriously threaten the supremacy of hydroelectric plants. The main points advanced are:

1. The immense first cost of a reliable water-power plant with good storage reservoirs, etc.

2. The low cost of steam turbines due to moderate first cost and the immense size of the units built, and especially the low cost of the generators used with turbines, in proportion to their output.

3. The low cost of attendance and maintenance of steam turbines, and the economy obtained with great overload capacity.

A Russian electrical exhibit will be given by the Russian Technical Society of St. Petersburg in April, 1911. The exhibition will be divided into three sections, viz: (1) The application of electricity to the working of steam railways; (2) the application of electrical energy to train traction on (a) main railway lines, (b) local railways, (c) tramways; (3) the application of natural water-power. A commission of experts will make reports to the Russian government in regard to such exhibits as are most prominent from the view of public utility, and also those that most fully correspond with the aims of the exhibition. The Minister of Commerce must confirm all awards. It is regarded as important that anything new in connection with electrical traction, especially electromotors, monorail lines, and the like, should be placed on exhibition.

SUBURBAN GAS DISTRIBUTION.

BY L. H. NEWBERT.

Suburban gas distribution is a subject of growing importance and interest to the gas fraternity; and, as the title indicates, this paper will deal primarily with the question of supplying gas to territory adjacent to the larger cities. As a rule, these large centers of population are surrounded by small towns, villages, and sparsely settled territory extending over a large area, the residents of which are eager to enjoy all the conveniences of the city and, hence, make good gas consumers. On the other hand, the cost of piping will be high on a basis of the number of consumers supplied and will always require a large capital investment. For obvious reasons the low pressure system with its large pipes is impracticable and prohibitive. To meet the conditions cited, a high pressure system must be employed; and, that it does fulfill all requirements has been the experience of the writer during a period of more than five years.

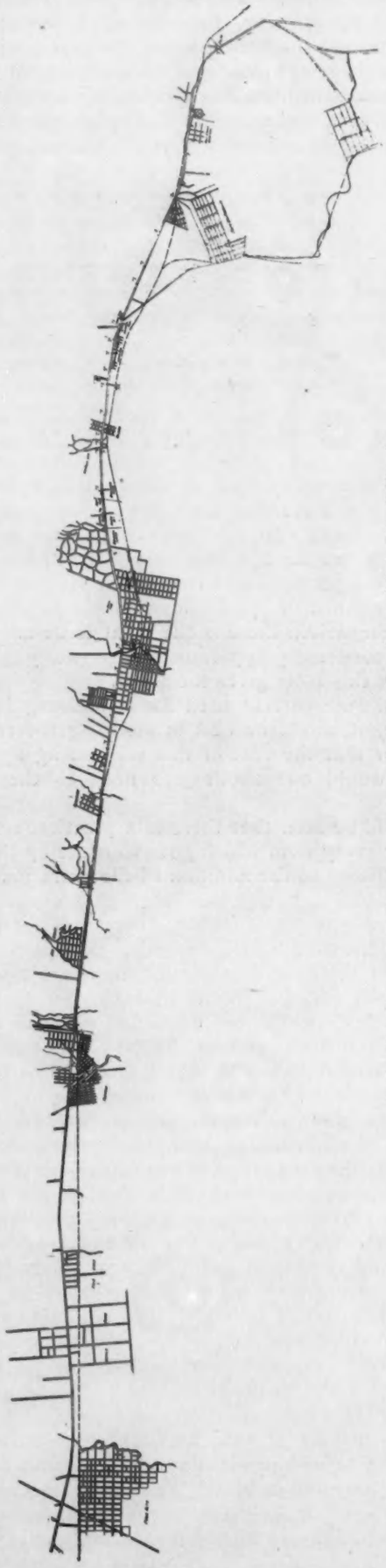
It must be of interest to note here that the distribution of illuminating gas under more than ordinary pressure was first undertaken, at least on the Pacific Coast, by the secretary of this association, Mr. John A. Britton, in the city of Oakland over twenty years ago when gas was conveyed from the Oakland works to a holder 2½ miles distant under a pressure of 15 lb. to the square inch. Subsequently, service was supplied to Berkeley under a pressure of 25 lb. through cast iron mains with lead joints. The mains were originally laid for low pressure service but proved satisfactory under the increased pressure. Today, as the result of the installation referred to, Oakland has an extensive system of high pressure distribution.

In 1901 the Los Angeles Lighting Company introduced high pressure distribution into the city of Los Angeles. A paper read by Mr. Luckenbach of the Los Angeles Gas and Electric Company before the sixteenth meeting of the Association describes in detail the beginning and subsequent enlargement of the system.

In 1902 the California Central Gas & Electric Company (a subsidiary company of the Pacific Gas & Electric Company) installed a high pressure distributing system to supply the towns of Grass Valley and Nevada City.

These installations, I believe, represent the commencement of high pressure gas distribution now so popular in this State, both for feeding into low pressure systems through district governors and for the supply of gas direct to consumers through service regulators in suburban territory as, for example, the district south of San Francisco lying between the coast foot-hills and the bay shore, commonly known as the San Francisco peninsula. Leaving San Francisco via Mission Road one finds this territory fairly well populated, there being four towns ranging from 3000 to 7000 population in a distance of 30 miles and the intervening districts well settled with individual residences —a territory in all respects suburban. As the entire peninsula district enjoys gas service, made possible only by resorting to high pressure distribution, a description of the system will illustrate, in general, the subject of this paper.

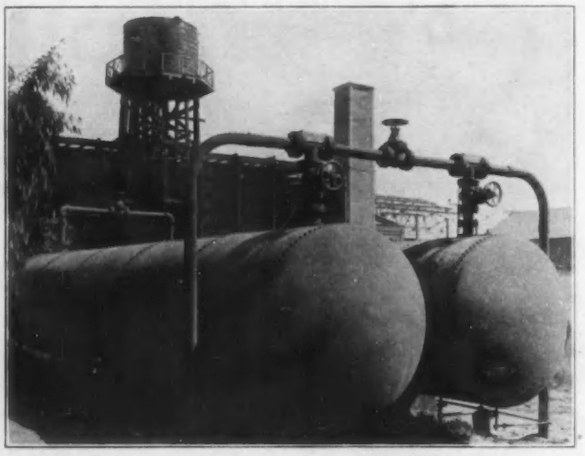
[1]Paper read at eighteenth annual convention Pacific Coast Gas Association, Los Angeles, September, 1910.



30 mile High Pressure Gas Distribution between South San Francisco and Palo Alto, California

In the northeast corner of San Mateo county, just beyond the line of the city and county of San Francisco, and on the shore of San Francisco bay, lies Visitacion Valley. Here is situated Martin Station, named for a former president of this association. It is from this point that gas is supplied to the aforesaid 30 miles of suburban territory lying between San Francisco and Palo Alto.

A four-inch pipe line extends from the receiving tanks at Martin Station to Redwood City, a distance of 25 miles. Three-inch pipe is then used for 4 miles, from Redwood City to Palo Alto. The line follows the main county road the entire distance and, when laid, was tested with air, the pressure employed being 100 lb. to the square inch. All joints are made with Dresser couplings which, to date, have been found quite satisfactory though a careful watch is kept for leaks, and a few have been found but were easily corrected by tightening the couplings. Compressors at Martin maintain an initial pressure on the main line

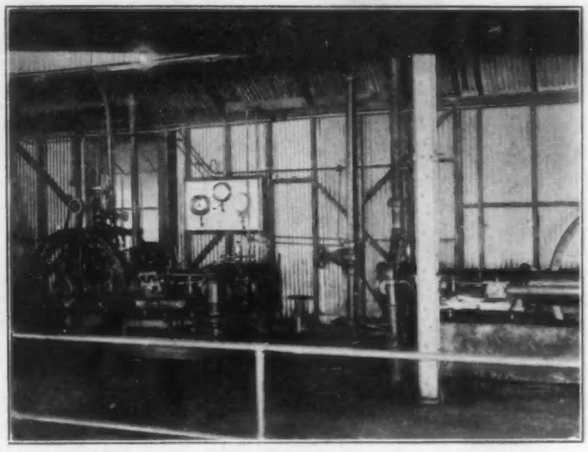


Compression Tanks at Martin Station. Gas from compressors passes into right hand tank, through connection at further end, into left hand tank, and out through pipe at left to main.

of from twenty to fifty-five pounds. For the twenty-four hours the pressures are approximately as follows:

		Martin.	Redwood.
1 a. m.	Compressors down	25 lb.	25 lb.
2 "	" "	25 "	23 "
3 "	1 compressor running	24 "	20 "
4 "	Compressors down	25 "	24 "
5 "	1 compressor running	23 "	21 "
6 "	2 compressors running	35 "	26 "
7 "	" "	45 "	28 "
8 "	" "	45 "	25 "
9 "	" "	44 "	25 "
10 "	" "	44 "	25 "
11 "	" "	45 "	27 "
12 m.	" "	48 "	28 "
1 p. m.	Compressor down	45 "	25 "
1 p. m.	Compressors down	45 "	25 "
2 "	1 compressor running	27 "	20 "
3 "	1 " "	30 "	20 "
4 "	1 " "	30 "	20 "
5 "	2 " "	50 "	27 "
6 "	2 " "	50 "	27 "
7 "	1 " "	50 "	24 "
8 "	1 " "	45 "	25 "
9 "	1 " "	40 "	28 "
10 "	1 " "	40 "	32 "
11 "	1 " "	40 "	33 "
12 "	Compressors down	30 "	29 "

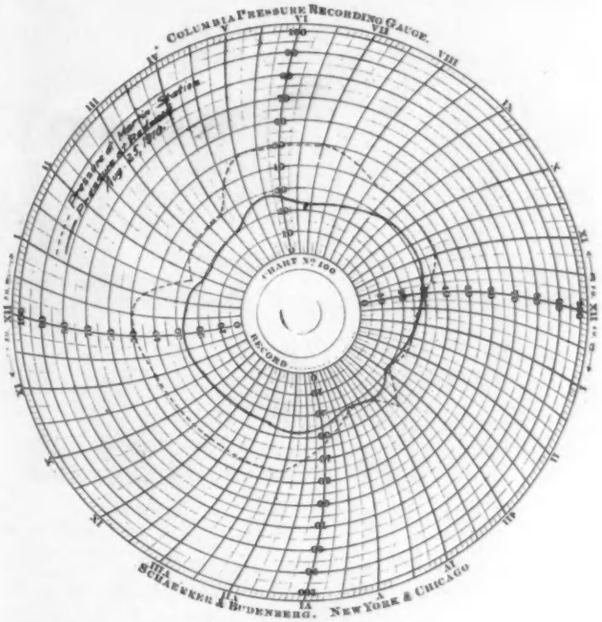
Consumers between Martin and Burlingame are supplied directly from the main line. At San Mateo a tap is made in the main line which supplies service to San Mateo, Burlingame and vicinity. This service is supplied through a four-inch governor which reduces the pressure to 10 lb. Two-inch pipe is usually employed for mains in these districts, though some smaller has been placed and has given satisfactory service, care having been taken to secure proper circulation by eliminating dead ends. No pipe smaller



Compressors at Martin.

than two-inch, however, is now used for mains, the idea being to carry lower pressure rather than small mains and higher pressure, for obvious reasons—leakage.

Four compression or storage tanks 6 by 30 ft., containing approximately 17,000 cu. ft. of gas, are installed at San Mateo, on which a pressure of 80 lb.



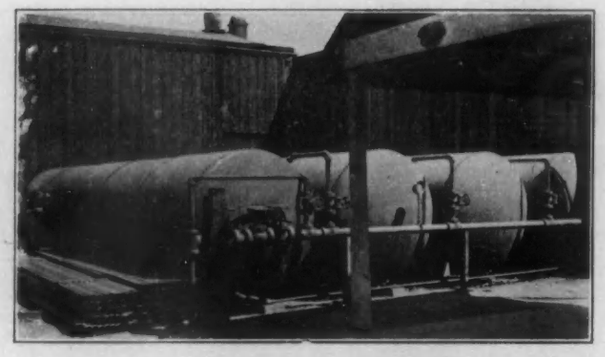
Pressure Gauge Record.

is maintained; and these are held in reserve in case a shutdown is necessary for repairs on the main line.

Consumers in the district intervening between San Mateo and Redwood City, a distance of eight miles, are supplied directly from the main line. Redwood City (excepting the business district, which is low pressure) and its immediate vicinity are supplied similarly to the San Mateo-Burlingame district; i. e.,

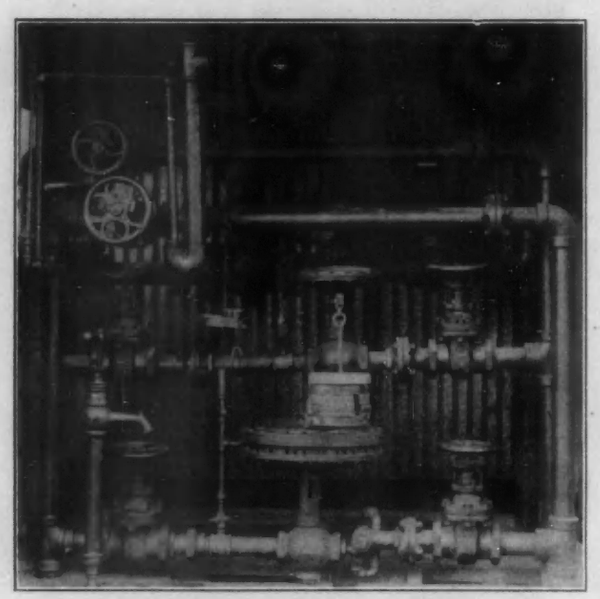
through a four-inch governor at 10 lb. Here six compressors or storage tanks, containing 25,500 cubic feet of gas, are installed and operated in the same manner as those at San Mateo.

The four miles of territory intervening between Redwood City and Palo Alto is the most thickly set-



Compression Tanks at San Mateo.

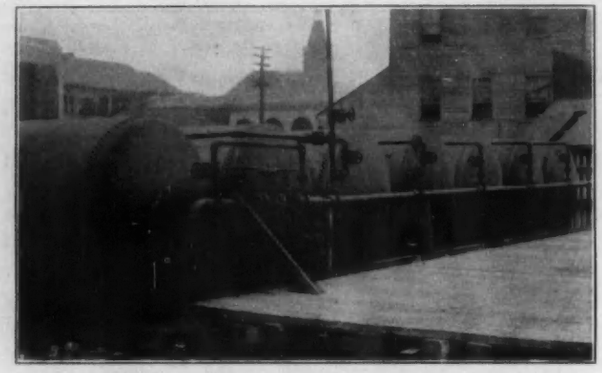
tled, truly suburban district on the peninsula, especially near the stations, Fair Oaks and Menlo Park. At the former place a distributing system consisting of two-inch main exists, service being supplied to the system from the main line through a two-inch district governor, and a pressure of ten pounds is maintained here also.



Governors on Lines Feeding Out From Redwood City.

At Menlo Park there is the only low pressure distributing system in the peninsula territory. A number of years ago a wealthy resident erected a gas plant and laid several thousand feet of four-inch mains to supply his neighbors The plant ceased operations after the earthquake of 1906 and the distributing system was taken over by the Pacific Gas and Electric Company. The mains were tested to 5 lb. gas pressure and found comparatively tight; but, as the four-inch mains provided ample capacity, it was decided to operate at low pressure. Accordingly, a district governor was installed in a waterproof manhole, which governor reduces the pressure from pounds on the main line to four and one-half inches on the distributing system.

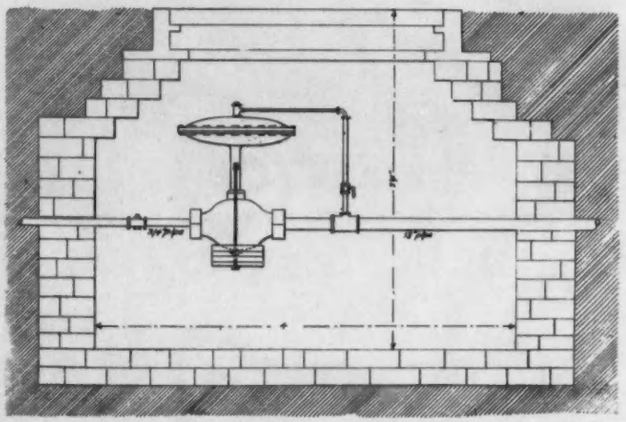
Service is supplied to Palo Alto through four compression or storage tanks located underground. Two district governors reduce the pressure to, approximately, ten pounds on the distributing system.



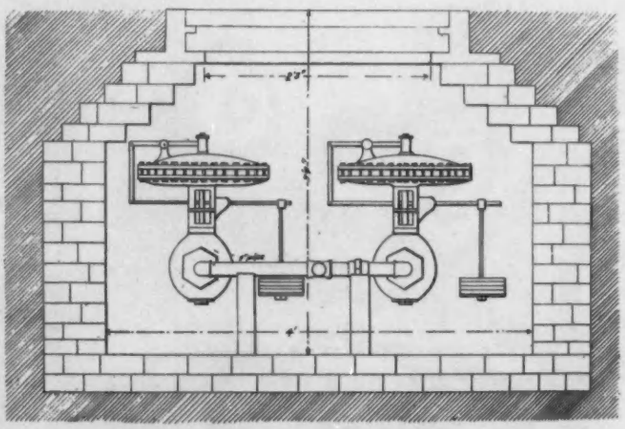
Compression Tanks at Redwood City.

Individual service regulators are installed on all services on the consumers' premises in a position easy of access and where, should the seal blow, the gas will escape outside the building.

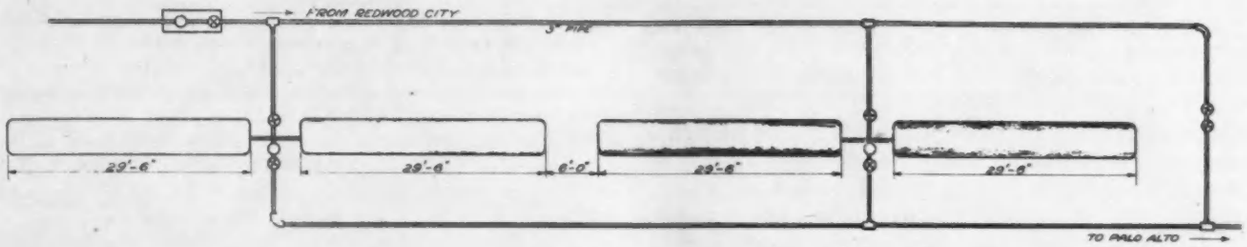
The regulators are adjustable and pressure may be varied from three to six inches. For service connection three-fourth-inch pipe is generally employed,



Manhole at Atherton Avenue and County Road, Fair Oaks.



Manhole at Oak Grove Avenue and County Road, Menlo Park.



Gas Tanks and Connections at Palo Alto.

though one-half has been found satisfactory for the smaller houses. Services are connected to the main by tapping and using service clamps with lead gaskets which make a perfectly tight joint.

The reader or auditor who follows the description of this system, because of its seeming complication, would naturally conclude that much attention will be

Service Regulator and Oil Seal as Installed with Meter.

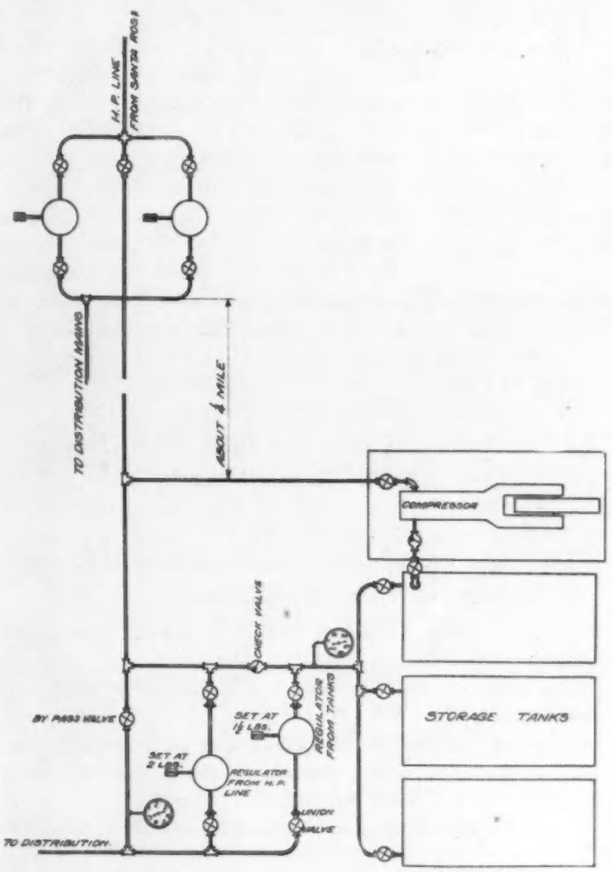
constantly required throughout the distributing territory. This is not the case. Comparative investigation and experience have demonstrated that this system is operated with less trouble and fewer complaints than low pressure, and the service to the consumer is all that can be desired.

The system briefly outlined in the foregoing pages serves a territory having at present a population of approximately 30,000 people, distributed over an area of about sixty-six square miles; hence, it may well be termed a system for supplying gas to suburban territory.

It is almost needless to state that the installation of a high-pressure system requires the utmost care, as a leak the size of a pinhole is like a plug out in a low-pressure system. All work should be performed with the greatest care and should be done under the supervision of a most painstaking foreman. All mains laid should be tested with air pressure considerably in excess of the gas pressure to be employed. For this work a portable air compressor should be used and pressure should be kept on for several hours.

When tubing is used and the joints are made with Dresser couplings, particular care should be taken to see that the flanges are drawn up evenly so that the pressure on the gasket is even, otherwise the flange is apt to bind on the pipe and a leak will develop.

Pipe used for high-pressure service should be most carefully coated with, at least, two coats of the best metal preservative. At this writing the writer is inclined to favor Biturine, especially in ground affected



Method of Installing Storage Tanks and Governors to Supply Peak Demand.

by tide water. When screw pipe is used a die should be run over the threads to insure proper cut. Line pipe sockets only should be used and the joint should be made with litharge and glycerine. All iron fittings should be extra heavy. Brass fittings, valves, etc., should be extra heavy and of the best workmanship.

While pipe as small as one inch has been employed in high-pressure systems, I favor using nothing smaller than two inch, even in sparsely settled territory, as the increased capacity will permit carrying lower pressures, which means less leakage.

While good results have been obtained by direct service from mains carrying as high as 75 lb., I do not think the practice should be encouraged. It is far better to keep the higher pressure lines free from service connections, using them only to convey the gas to a central point, or points, where the pressure should be reduced, for the distributing system, as low as the demand on the system will allow. This can be ascertained by taking pressures occasionally some distance from the distributing center with a recording gauge. A battery of storage tanks should be installed at the distributing center of sufficient capacity to meet peak requirements. These should be filled from the main line by means of a compressor at off peak times and turned into the distributing system by means of an automatic governor when the pressure on the distributing system falls to a certain pressure. An installation of this kind exists at the Petaluma plant of the Pacific Gas and Electric Company and the results are most satisfactory. The arrangement is clearly shown in the drawing herewith.

Another point which must not be overlooked on a high-pressure system is the care of service regulators. Regular inspections should be made to see that they are in proper working order. If this is done the service should be as near perfect as possible.

As yet, metering large quantities of gas under high pressure has not been successfully done, but both the Rotary Meter Company and the St. John Meter Company will shortly place on the market meters which promise to be satisfactory. The Pacific Gas and Electric Company intend trying these meters out and some interesting data should be obtainable at the next meeting of this Association.

Varying conditions will necessarily produce varying requirements for each suburban territory, but, in a general way, the foregoing will apply to any suburban district.

DISCUSSION ON STEAM ENGINEERING PRACTICE.[1]

A Few Hints on Scotch Boilers.

A Scotch boiler as usually termed, is a steel, cylindrical, longitudinal, wet bottomed, marine boiler.

The advantages of corrugated furnaces over plain furnaces are: (a) better for expansion, (b) more metal, (c) diameter and not the diameter squared as with the plain furnace, (d) corrugations strengthen the furnace, (e) more heating surface for the same length.

The main stays are usually from 2 in. to 3 in. in diameter and pitched at from 14 in. to 16 in., and are arranged in horizontal and perpendicular lines. The stress allowed is 7000 lb. if iron and 9000 lb. for steel per square inch.

Boiler overheating is caused by shortness of water; allowing the water to become too dense; accumulation of scale on the heating surfaces; deposits of oil on the heating surfaces; or plates too thick, as furnaces 1¼ in. thick would burn down until they were ⅝ in. thick.

Boiler priming is caused by dirty water, or hard firing. The remedy is to open the cylinder drain cocks and slow down the engine until water is steady again in the gauge glass.

If when blowing down the boiler the blow down cock becomes jammed, slack the gland and ease the cock, as this may be due to unequal expansion between the cock and shell.

Getting up steam in a Scotch boiler should never be attempted in less than 12 hours, that is from the moment of lighting the fires until you have working pressure. If possible take 24 hours, for the slower the boiler is heated the more equal the expansion, as in this case the bottom of the boiler gets every chance to heat as well as the top. Keep the donkey pump circulating the water in the boiler for a few hours, or better if you have a hydrokineter use it.

If a boiler rivet is leaking badly, draw fires and blow down boiler, then knock out rivet and put in a bolt which would do temporarily until a chance could be had to put in a new rivet.

If a broken check valve stem cannot be adjusted, regulate the feed water by means of the main throttle valves. If there is more than one boiler, shut down the throttle valve on whichever boiler has most water in it. If only one boiler use auxiliary or donkey check valve to regulate feed water.

If the bottom seams leak, dress and caulk, and use due precaution in the heating up of the boiler.

The manhole door and manhole are made oval, to allow the door to be taken out and put in at will as the door is larger than the manhole. If square or round the door would always have to stay inside the boiler and would be in the way for inspection and cleaning.

Fire-bars should have a droop of one inch to every foot length. If grate length is five feet, the droop is five inches. If the furnace is three feet in diameter two feet should be the height of fire brick, leaving one foot for the heat and flame to pass into the fire box. If arch bricks are used the height of beaters and fire bricks should then be three inches less, as the arch bricks are generally about 3 in. thick. The arch bricks are used to save the rivets of the furnaces as the greatest heat goes on the brick. When cleaning fires the arch bricks are often knocked down and this is one of the reasons that the engineers have not used them permanently. If short of fire clay and the bricks are loose a very good plan is to break up a few fire bars to the proper length and place them between the bricks. The excessive heat melts them between the bricks and they adhere to the bricks and make a very good substitute for clay.

How to fire a Scotch boiler:

(1) Place some wood on top of fire bars and then apply a piece of waste with some oil on it between two layers of the wood and then cover same with a thin coating of coal, then apply a light.

(2) Keep a slow fire burning to warm up the boiler slowly, say for 4 to 6 hours. Let the steam rise easily as forcing the boiler means leaky rivets and seams owing to the unequal expansion of the top and bottom of the boiler.

(3) Use the circulating pump, usually a Weir's or vertical donkey pump.

(4) At sea a good fireman waits until the coal is red all over before putting on the next fire. It is a good plan when throwing the coal in to let the fireman's shovel lightly touch the front of fire entrance as the coal then spreads over the fire. Push the coal which has been half burned from the front of the furnace to the back and throw the green coal on at the front. This means that you are getting the most heat and at the same time the heat from the glowing coals will be consuming the gases in the smoke which is passing from the green coal at the front.

(5) Use the fire-hoe to keep the fire level and see that the fire-bars are covered or otherwise there will be a loss in the draught and a poorer fire and less steam.

(6) Pass the slice bar occasionally under the coal, easing the clinker and letting the air pass through freely.

CHARLES MORTON.

[1]California No. 3, N. A. S. E.

CURRENT COMMENT

The Denver Electrical Show opens on October 8, continuing one week thereafter.

A rotary air compressor capable of compressing twenty thousand cubic feet of free air per minute to a pressure of 118 pounds is being manufactured in Germany. The compressor runs at 4000 r.p.m. and has twelve stages.

A new Peruvian electric railway is to be built for 80 miles between Ancon and Huacho. It is to be operated by power to be developed from the river Chancay, or Pasamayo. Any excess of power is to be sold to the sugar plantations.

Increased membership in I. E. S., the Illuminating Engineering Society, is reported as a result of the campaign started by J. Robert Crouse in June of this year. The addition of 500 names represents an increase of 50 per cent in the total membership.

Examination for clerk-draftsman is announced by the United States Civil Service Commission on October 19-20, 1910, to fill vacancies as they may occur in the position of clerk-draftsman in offices of surveyors general, Land Office Service, at salaries of about $4 per diem or $1200 per annum.

An electrically cooked dinner for 18 persons, the dinner including soup, roast beef, Lima beans, potatoes, shortcake and coffee, was recently served at Chicago. The entire operation took two hours and required 2310 watthours which at 10 cents cost 23.1 cents, an average of 1.28 cents per person.

The statue of Lord Kelvin, by Mr. Albert Bruce-Joy, which is to be erected in Belfast, Ireland, Lord Kelvin's birthplace, is nearly ready. The figure stands 10 feet high. On the right hand is a design of Kelvin's gyroscope, and on the left a model of the Kelvin compass. The statue will be cast in bronze.

The hot wire system for tungsten lamps is being used on Eastern railroads to minimize breakage. A small current, keeping the filament at a dull red, is always on the line, thus giving longer life to the filament. The lamps are lighted from storage batteries at 60 volts, this being reduced to 4 volts when the lamps are extinguished.

A combination engine and boiler has been developed in Germany to give one horsepower hour per pound of coal burned. The cylinder and steam dome are cast in one piece and riveted to the boiler shell. This eliminates radiation and condensation in long steam pipes and utilizes the waste heat from the furnace gases in superheating the steam.

Newly elected national officers of the N. A. S. E. at the Rochester convention in September are Carl S. Pearse, Denver, Colo., president; Edward H. Kearney, Boston, Mass., vice-president; Fred W. Raven, Chicago, Ill., secretary; Samuel B. Forse, Pittsburg, Pa., treasurer; Joseph J. Gibney, Mobile, Ala., conductor; W. H. Lockett, Dallas, Tex., doorkeeper.

Examination for assistant forest rangers is announced by the Civil Service Commission on October 24-25, 1910. The U. S. Department of Agriculture estimates that 400 eligibles will be needed during the field season of 1911. Assistant forest rangers are paid an entrance salary of $1100 per annum. The examination will be held at National forest headquarters throughout the Western States.

Amateur wireless operators are organizing under the direction of George Hiram Mann, an attorney of Washington; first, to defeat the Depew bill; second, to secure the passage of the Roberts joint resolution, which provides a commission to take testimony before any legislative action is adopted, and, third, to secure an expression on behalf of all the amateurs, favoring some positive legislation which will give them protection.

A potato as a polarity indicator is described by a writer in Power. Upon inserting the two current carrying wires into a freshly cut surface a green stain due to dissolved copper indicates the positive wire. If both wires are surrounded by dark colored stains the current is alternating. Another method is to hold a bar magnet near a lighted incandescent lamp. If the current is alternating the filament will vibrate, if direct it will be attracted or repelled according to the sign of the magnet pole presented.

Average daylight, as defined by Ives closely corresponds to the light emitted from a black body at 5000 degrees absolute. As shown by the Ives colorimeter its sensation values for red, green and blue are 33 1-3 per cent for each. Of all the artificial illuminants the Moore carbon dioxide tube has been found to be nearest to this standard, being 31.3 red, 31.0 green and 37.7 blue. As time has advanced the tendency has always been toward a whiter light from the open fire place, to the candle, to the ordinary oil lamp, to the gas lamp, to the carbon incandescent, to the Welsbach, to the Nernst, to the tungsten, to the acetylene, to the arc lamp, to the Moore tube.

Coal briquettes were produced in the United States last year in greater quantity than ever before, according to the U. S. Geological Survey, but the output is still insignificant compared with the 18,000,000 tons made annually in Germany. The American product in 1909 is reported as 139,661 short tons, valued at about $453,000. This is an increase of 54 per cent over the production of 1908. The reason for the much greater production in Germany is stated to be the cheapness of labor there, the greater cost of coal, and the practice of coking coal in retort ovens which yield a large quantity of pitch suitable for use as a binding material for briquettes. The Geological Survey states that here the briquette industry is held back by the large supply of cheap natural fuel, by the high cost of labor, and by attempts to exploit secret processes for which extravagant claims are made but which have failed to make good.

JOURNAL OF ELECTRICITY
POWER AND GAS

PUBLISHED WEEKLY BY THE

Technical Publishing Company

E. B. STRONG, President
A. H. HALLORAN, Vice President and Managing Editor
C. L. CORY, Secretary.

DIRECTORS

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604 MISSION STREET, SAN FRANCISCO

EASTERN OFFICE, 150 NASSAU STREET, NEW YORK
C. N. MANFRED, Eastern Manager
LOS ANGELES OFFICE, 107 SECURITY BUILDING

TERMS OF SUBSCRIPTION

United States, Cuba and Mexico	per year,	$2.50
Dominion of Canada	"	3.50
Other Foreign Countries within the Postal Union	"	5.00
Single Copies, Current Month	each	.10
Single Copies, prior to Current Month	"	.25

NOTICE TO ADVERTISERS

Changes of advertising copy should reach this office *ten days in advance of date of issue.* New advertisements will be accepted up to noon of Monday dated Saturday of the same week. Where proof is to be returned for approval, Eastern advertisers should mail copy at least thirty days in advance of date of issue.

Entered as second-class matter at the San Francisco Post Office as "The Electrical Journal," July 1895.
Entry changed to "The Journal of Electricity," September, 1895.
Entry changed to "The Journal of Electricity, Power and Gas," August 15, 1899.
Entry changed May 1, 1906, to "The Journal of Electricity, Power and Gas." Weekly.

FOUNDED 1887 AS THE
PACIFIC LUMBERMAN, CONTRACTOR AND ELECTRICIAN

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Entropy

When a child first learns to add he cannot deal with abstract numbers but requires some familiar object, such as apples or blocks, as a sort of mental crutch to assist his understanding. We all employ such artifices in trying to comprehend complex subjects. The Saviour spoke in parables. The attraction of gravity or of magnetism may be explained by the assumption that they act along lines of force. The hydraulic analogy simplifies the mystery of electricity. Meridians of latitude and of longitude help the surveyor and geographer. But parables are not literally true; there are no actual lines of magnetic force; neither is electricity water; nor the equator "a menagerie lion running around the center of the earth."

Among the most difficult subjects to comprehend is the science of thermodynamics which gives a mathematical explanation of the work done by steam in an engine. By drawing a diagram of what takes place these difficulties are somewhat simplified. Every steam engineer is familiar with such a diagram in an indicator card which represents the steam's work as an area equal to a summation of the product of the volume and the pressure at all points in the piston movement. Most engineers know how to compute the indicated horsepower from the mean effective pressure thus determined, and how to calculate the indicated steam consumption with the assistance of steam tables. But when it comes to finding the character of the expansion and determining the loss due to cylinder condensation and to wire drawing the indicator diagram is not satisfactory.

This inadequacy may be obviated by the use of an entropy diagram. Entropy is one of the most illusive, intangible and least understood of all engineering terms. Heat is assumed to be a compound quantity consisting of two factors, one the absolute temperature, the other entropy. Just as work is graphically represented in the indicator diagram as the product of pressure and volume, so is heat imparted diagrammed as the product of temperature and entropy. In the steam tables entropy is given as a decimal fraction which has been computed by the methods of higher mathematics.

The value of this factor for water increases from 0 to 0.67 as the absolute pressure increases from 0.0886 to 600 pounds per square inch, while the entropy of evaporation correspondingly decreases from 2.1832 to 0.783.

The physical conception of this "ghostly quantity" which cannot be perceived by the senses or measured by any gauge or meter is as difficult as is that of the fourth dimension. For all practical purposes it is sufficient to accept it merely as a length in a diagram or as an abstract numerical quantity in the tables, largely as a matter of faith, being much like religion in this respect. Before the commercial development of the steam turbine most engineers side-stepped this question, but now it is necessary for them to go back and brush up on the subject. Rightly applied it is a powerful tool in attacking steam problems. It is not necessary to bother about what entropy is, but it is certainly advisable to find out what can be done with this device.

PERSONALS.

A. M. Hunt, electrical engineer, left on a trip to San Diego last Tuesday.

K. Kasper, who has electric lighting interests at Vallejo, spent last Tuesday at San Francisco.

K. G. Dunn, engineer with Hunt, Mirk & Co., has returned to San Francisco, from a northern trip.

R. S. Buck, of the engineering staff of Sanderson & Porter, is expected in California about October 15.

J. F. Meister has been appointed instructor in electrical engineering at the Oregon Agricultural College, Corvallis, Oregon.

H. A. Lardner, manager of J. G. White & Co.'s Pacific Coast office, returned to San Francisco last week from Los Angeles.

John Coffee Hays, general manager of the Mt. Whitney Power Company, of Visalia, was a San Francisco visitor during the past week.

A. W. Vinson, representing Cutler, Hammer Mfg. Co., as engineer, with Otis & Squires, has been transferred to the home office at Milwaukee.

H. A. Tedford, general superintendent of the Northern California Power Company, spent last Tuesday at the company's San Francisco office.

George Hawkins, with Chas. C. Moore & Co., engineers, recently returned to San Francisco with several good contracts from the Hawaiian Islands.

Thomas Mirk, of Hunt, Mirk & Co., Pacific Coast representatives of the Westinghouse Machine Co., left last Monday for Los Angeles and San Diego.

Leon M. Hall, of Hall, Demarest & Co., spent the past week in Merced County, on engineering work connected with the construction of irrigation dams.

George I. Kinney, Pacific Coast manager for the Fort Wayne Electric Works, has returned to his San Francisco office after paying a visit to Los Angeles.

E. H. Rose of Los Angeles has been appointed manager at Maricopa, Cal., for the Midway Light & Power Co., which recently took over the interests of the West Side Electric Company.

Cary T. Hutchinson, a consulting electrical engineer at New York City, is examining the plant of the Klickitat Valley Development Co. under construction near Glenwood, Washington.

H. T. Edgar has been appointed manager of the Seattle Electric Co. Since 1898 Mr. Edgar has been manager of Stone & Webster properties at Lowell, Mass., and at El Paso, Texas.

F. B. Gleason, manager of the Western Electric Company's San Francisco branch, recently returned from a trip to Salt Lake City, and reports that business has improved all along the line.

A. L. Searles, manager of the electric rock drill department of the Fort Wayne Electric Works, left Los Angeles last Saturday for Madison, Wis., after spending several weeks on the Pacific Coast.

W. N. Winter has been elected manager of the Home Telephone Company at Hood River, Ore. Charles Hall, president of the company, who has been manager of the system, will be the managing director.

George Spaulding, representing E. M. Burgess, the general manager of the Colorado Telephone Company, has arrived at San Francisco from Denver and is inspecting the Pacific Telephone & Telegraph Company's system.

H. M. Byllesby, head of H. M. Byllesby & Co., of Chicago, is at San Francisco on business connected with investments in electric power plants in California and elsewhere. He was accompanied by A. F. Stevens, of his engineering staff.

H. C. Deering, manager of the Humboldt Gas & Electric Company of Eureka, Cal., has been at San Francisco.

H. C. Goldrick, Pacific Coast manager of the Kellogg Switchboard & Supply Company, has returned to his San Francisco office after a Southern California tour.

R. E. Starkweather, who has has charge of the construction of the Great Western Power Company's transmission lines for the past two years, has resigned his position to engage in private construction work, particularly of pole lines.

A special board of army engineers, appointed by President Taft to inspect and report upon the Government reclamation projects now under way, were at San Francisco during the past week, accompanied by F. H. Newell, director of the reclamation service. The personnel of the party included Brigadier-General W. L. Marshall, advising engineer; Colonel William C. Longfit, Lieutenant-Colonel John Biddle, and Majors William W. Harts, Charles W. Kutz and Harry Burgess. The work already inspected includes that on the Truckee-Carson project at Fallon, Nev., and the Government irrigation project at Klamath Falls, Ore. The Imperial Valley project, in California, will next be investigated.

TRADE NOTES.

Geo. F. Willoughby has bought the business of the Hunter Electric Co. at Eugene, Oregon, and will conduct it in his name.

The Burton R. Stare Co., dealers in electrical supplies at Seattle, have moved to enlarged quarters at 115 Prefontaine Place.

James C. Maitland has bought out the interest of P. H. Ridgway in the Electrical Engineering Co., electrical contractors, 112 Marion street, Seattle.

The office of the Western Carbon Battery Co., has been removed from the American Bank building, Seattle, to the factory, 1906 Seventh avenue, near Westlake, Seattle.

The Westinghouse Electric & Manufacturing Company has recently received an order from the Simonds Manufacturing Company for six 500 k.v.a. O. I. S. C. transformers, two 200 h.p. type HF rolling mill motors to be used in the new Lockport, New York, plant of the purchaser. The transformers will be used in stepping down the power purchased at 12,000 volts to 480 volts. One of the motors will be used on the band sawmill and the other on a cross cut sawmill. The motors will be geared to the mills, which will consist of two stands each. The motors will be of the Westinghouse extra heavy rolling mill type, so constructed as to permit the moving of the stator sideways in case of necessary repairs to the rotor.

J. G. White & Company, Inc., have been awarded a contract for the engineering and construction of a steam and electric power plant to be built for the Power Transit & Light Company, at Bakersfield, Kern County, California. The building will be 82 feet by 140 feet, with substructure of concrete, self supporting steel frame, and walls of metal lath and plaster, which is the usual form of construction throughout lower California, and will be designed to accommodate two 2000 kilowatt horizontal turbines, with boilers, condensers and necessary auxiliaries. A 750 kw. turbine will be temporarily installed at the earliest possible date. Water for condensing purposes will be obtained from an irrigation ditch near the plant, and the water for boiler purposes will be supplied from wells to be driven near the power house. As the boilers will be installed with oil burners, there will be no basement under the boiler room. The station will be designed electrically to deliver practically full load at either 60,000, 10,000 or 2300 volts, and will operate at all the above pressures simultaneously. The estimated cost is approximately $400,000.

INDUSTRIAL

WHAT ONE CENT'S WORTH OF ELECTRICITY WILL DO.

The Southern California Edison Company of Los Angeles has prepared the following data on the current consumption of various household appliances whose chief delights are their convenience, cleanliness and the fact that many dishes may be electrically prepared upon the dining table:

Coffee Percolator.

One cent's worth of electricity will make six cups of delicious coffee in an electric percolator, which is operated upon the dining table, requiring no service from the kitchen. The percolator is as beautiful as the coffee urn and an ornament to the table.

Electric Water Boilers.

One cent's worth of electricity will bring to a boil four quarts of water, or operate the baby milk warmer two times. These water heaters are adaptable for boiling eggs on the dining table, or any purpose for which hot water is required.

Electric Sewing Machine.

One cent's worth of electricity will operate an electric sewing machine motor for five hours. This little device attached to an ordinary sewing machine takes away all of the hard work incident to the family sewing.

Electric Heating Pads.

One cent's worth of electricity will keep an electric heating pad hot for three hours. These pads are provided with the thermostat, which automatically prevents the temperature from becoming too high. Indispensable for the sick room and the sleeping porch.

Electric Shaving Mugs.

One cent's worth of electricity will heat water in an electric shaving mug for twelve shaves. The water is heated almost instantly, and if the current is turned on upon arising, plenty of hot water will be available for the morning shave.

Electric Chafing Dish.

One cent's worth of electricity will operate the beautiful electric chafiing dish, which has come to be a feature in society luncheons, long enough to make a Welsh rare-bit.

Electric Broilers.

One cent's worth of electricity will run an electric broiler for ten minutes. The broiler is also intended for use on the dining table. The broiler will prepare chops and steaks for the meal while the coffee is making in the percolator.

Electric Disc Stoves.

One cent's worth of electricity will keep an eight-inch disc stove hot for fifteen minutes. The electric disc stove is an appliance which can be used for many purposes. It is handsome in design.

Electric Griddles.

One cent's worth of electricity will operate an electric griddle for fifteen minutes. These appliances are highly appreciated by families who are fond of hot cakes. With the electric griddle they can be cooked upon the table. No trotting from kitchen to dining room with every plate of cakes.

Electric Foot Warmers.

One cent's worth of electricity will keep an electric foot warmer hot for thirty minutes. The current is turned on and the surface is just large enough to place the feet upon and radiate the proper amount of heat to warm the feet without overheating the room or vitiating the air.

Electric Flatiron.

One cent's worth of electricity will keep a six-pound electric flatiron hot for fifteen minutes. This is long enough to do the dainty family ironing, such as fabrics that are too fine to entrust to your Chinaman.

Luminous Radiators.

One cent's worth of electricity will operate the luminous electric radiator for twelve minutes, wihch is long enough to heat the bed room while dressing, take the chill off the dining room in the early mornings and heat the bath room. Its use for heating small rooms is within reach of all our consumers.

The Electric Toaster.

One cent's worth of electricity will heat an electric toaster for fifteen minutes, which will make about twenty slices of toast. The toaster is made especially for the dining table, but it is often used at the bedside and in the sick room. This is an ideal small appliance.

Electric Toaster Stove.

One cent's worth of electricity will operate the electric toaster for fifteen minutes. It is a generally utility appliance for light work and will make hot cakes, toast, coffee, broil chops, heat water and fry eggs, and a number of other things, and is absolutely indispensable.

Electric Tea Kettles.

One cent's worth of electricity will operate an electric tea kettle for fifteen minutes . These kettles are furnished in two capacities—for two and four quarts. The two-quart has two heats—high and low heat; and the four-quart kettle three heats.

PERE MARQUETTE USING TELEPHONES FOR TRAIN DISPATCHING.

The Pere Marquette is soon to join the already long list of railroads using the telephone to dispatch trains, supplanting the telegraph, which was considered the standard for handling train movements for a great many years.

The Pere Marquette has ordered instruments, selectors and line material to equip a line from Saginaw, Michigan, to Toledo, Ohio, approximately 135 miles in length, with the telephone for train dispatching. This is understood to be the beginning of the adoption of the telephone system over the entire road, extensions to follow the completion of the first circuits.

Between Saginaw and Toledo there will be thirty telephone stations. The chief dispatcher will be at Saginaw. The entire equipment is being furnished by the Western Electric Company.

Because of the great ease and facility of transmission, the telephone has in the past couple of years been making rapid strides into favor among railroad managers. It performs the work formerly done by the telegraph in a more rapid and efficient manner, and the adoption of the telephone standard by a great many of the largest railroads in the country has caused a complete change in dispatching methods.

Braun, Williams & Russell, Inc., mechanical engineers and contractors, 503 Market street, San Francisco, announce that the name of the firm formerly known as the Standard Engineering Company, of 503 Market street, has been changed so as to incorporate the names of the members and in the future will be known as Braun, Williams & Russell, Inc.

NEWS NOTES

FINANCIAL.

MITCHELL, ORE.—The Council has passed an ordinance providing for the issuance of bonds in the amount of seven thousand dollars for the purpose of constructing waterworks to supply the town with water.

SAN BERNARDINO, CAL.—A certificate of bonded indebtedness in the sum of $150,000 has been filed with the County Clerk by the Yucaipa Water Company No. 1. The bonds run twenty years and bear 6 per cent interest. It is proposed to use the money obtained from a sale of bonds in completing the water scheme planned for Yucaipa Valley.

INCORPORATIONS.

EI CENTRO, CAL.—The Imperial Valley Electric Co. has been formed here for the manufacture of electric fixtures.

TENINO, WASH.—The Mud River Coal & Gas Company, capital $500,000, has been incorporated by N. H. Truett and Geo. F. Clement.

CARROLTON, WASH.—The Mount Pleasant Telephone Company, capital $300, has been incorporated by C. H. Wood and Mont Barber.

SEATTLE, WASH.—The Alaska Radio Telegraph Company, capital $250,000, has been incorporated by Lee DeForest, Edwin H. Flick, Leary building and Walter Loewe.

LOS ANGELES, CAL.—The Valley Water Company has been incorporated by F. D. Lanterman, B. Hayman, G. H. Stoll, F. G. Haven and W. T. Somes, with a capital stock of $6500.

SAN FRANCISCO, CAL.—The Marin Improvement & Water Company has been incorporated by G. G. Vickerson, S. N. Darbee and J. R. Moulthrop , with a capital stock of $10,000.

HONOLULU, H. T.—The Honolulu Electric Co., Ltd., has been incorporated by H. E. Martinez, A. J. Greene, C. C. Bitling, C. L. Sebolt and A. K. Ozaiva, with a capital stock of $50,000.

ONTARIO, CAL.—The Mayamar Water Company has been incorporated by G. A. Hanson, C. E. Sears and I. C. Baxter, who have purchased the water bearing acreage at the mouth of the San Antonio canyon.

MARTINEZ, CAL.—The California Natural Gas Company has been incorporated by H. D. Pillsbury and Alfred Sutro of San Francisco, C. C. Sullivan of El Valano, F. D. Madison and E. T. Zook of San Rafael with a capital stock of $1,000,000.

WHITE SALMON, WASH.—An incorporation of White Salmon and local capitalists capitalized at $10,000 have launched a campaign to secure $2,000,000 for the construction of an electric railway line from White Salmon to the upper White Salmon valley. Survey has been completed as far as Robertsville.

ILLUMINATION.

ALBANY, ORE.—It is announced that a gas franchise will be granted to P. G. Rowe and that a plant to cost $100,000 will be erected.

QUESNEL, B. C.—Wallace McMullan is promoting a scheme for installing an electric light and power plant here to be run by steam.

BOZEMAN, MONT.—A gas franchise has been granted to Dr. Carl Schroeter and J. C. McCarthy. The plant to be erected will cost $100,000.

CORVALLIS, ORE.—P. G. Rowe has asked for a gas franchise to begin the construction of a plant within six months if franchise is granted.

LONG BEACH, CAL.—The stockholders of the Inner Harbor Gas Co. have voted in favor of selling the business and property to the new Consolidated Gas Company, which is taking over the properties of this and the Edison Company here. The new company will proceed at once with an issue of bonds.

RIVERSIDE, CAL.—The Southern California Edison Company has taken out a permit for the erection of a brick building at the site of its gas plant at Pachappa avenue and Tenth street. The structure will house the compressor and other machinery to be installed. Pipes have been laid which will enable the company to supply gas to Arlington.

BISBEE, ARIZ.—Enlargement of the gas plant and the extension of the lines of the Bisbee Light and Power Company will be started by the last of October or the first of November. The plant will build pipe lines to Upper Lowell and Warren besides being generally extended over town to give service to those parts of the city that are now at some distance from the mains.

SANTA CRUZ, CAL.—After installing the second municipal lighting and power plant in the State the city has accepted the offer of the Coast Counties Light & Power Company under a new contract for a specified number of years. The proposition submitted by Waldo S. Coleman of the Union Traction Company was accepted by the City Council. Under the terms arc lights for lighting the entire city will be furnished at $4.50 per arc per month.

OROVILLE, CAL.—Electric lights and power will soon be available at low rates for the growing mountain towns of Paradise, Orloff, Stirling and many other smaller points in the northern foothill section. W. T. Hanscom, who owns a great deal of land in that section, has filed a notice of the appropriation of 1500 inches of water to be taken from the banks of Big Chico creek. The water will be carried in an 8-foot ditch to the location of the power house where electricity will be generated.

TRANSPORTATION.

BISBEE, ARIZ.—Surveyors are at work platting the extension of the car line for the Warren-Bisbee Street Railway Company to the city limits.

WALLACE, IDAHO.—The directors of the Hypotheek Mining Company are considering the question of installing a $12,000 electric power plant at the Kingston mine.

LONG BEACH, CAL.—It is understood that work is about to be resumed on the construction of the fourth five-mile division of the Yueneme, Malibu and Port Los Angeles railway.

NEW WESTMINSTER, B. C.—The local and the Ladner, B. C., Board of Trade will hold a conference to discuss the advisability of establishing an interurban line from this place to Ladner.

VANCOUVER, B. C.—The Barkerville Willow River Company is undertaking a survey for an electric road from Barkerville down the Willow river to join the Grand Trunk Pacific at or near Fort George, a distance of 120 miles.

LOS ANGELES, CAL.—The City Council has passed an ordinance which makes Alvarado street a boulevard and forbids a franchise for the proposed cross town car line. A franchise will be asked over either Vermont or Western avenues.

VICTORIA, B. C.—Incident to the transfer of the holdings of the Dunsmuirs to the Canadian Collieries, Ltd., a $1,000,000 power plant is to be erected on the Puntlage river in the center of the Comox coal measuers. The plant will be of 50,000 horsepower capacity.

SAN FRANCISCO, CAL.—The casualty report of the United Railroads for the quarter ending June 30, filed with the Board of Supervisors shows 10 fatal accidents. The list is completed with 347 other personal injuries, attributed to various causes, including assaults, alighting from cars, stepping in front of cars in motion, falling from cars, etc.

GLENDALE, CAL.—The proposed electric railroad between Glendale and Burbank is practically assured. Mr. Huntington has promised the Burbank people that as soon as the right of way and bonus are secured, he will begin work and complete within six months.

PRESCOTT, ARIZ.—The contract for the construction of the Arizona Power Company's low elevation line in Verde Valley, has been awarded to William Nagle and Ed. Kurmier. The line will extend 40 miles from the plant on Fossil Creek to Jerome; $100,000 will be expended.

PORTLAND, ORE.—Archie Mason has been awarded the contract to build the grade for the Mount Hood Railway Company, between Montaville and a point beyond Gresham. Work is to begin at once and will be under the direction of Smith, Kerry & Chase, an English firm of Toronto, Can.

SAN RAFAEL, CAL.—At a meeting of the board of town trustees the petition of W. L. Courtright, a real estate dealer and capitalist, for a street railway franchise of 49 years was ordered to be published and November 21 set for acting upon bids. Courtright purposes to build a street railway traversing the main thoroughfares of the town.

PORTERVILLE, CAL.—The directors of the Holley Electric Railway Company have purchased a power plant site of ten acres from D. Grider, above Springville. S. E. Henley, connected with the line, states that the dam for the power plant is to be located immediately below that of the Globe Light & Power Company and that work upon the construction of the plant would start within a very short time.

OAKLAND, CAL.—Work is well under way on the steel towers which will carry the big power cable of the Great Western Power Company across the channel at the foot of Peralta street. This cable will be hung high enough to allow ships with the tallest masts to pass under it. It is supposed that the S. P. intends to use electric power in its West Oakland shops, and that this is the primary reason for carrying the cable across at this point.

LOS ANGELES, CAL.—The first formal step toward the ultimate construction of a municipal railway from the business center of Greater Los Angeles to the harbor district at Wilmington and San Pedro was taken by the Council this week. By resolution, introduced by Mr. Gregory, the Council requested the Board of Public Works to report the feasibility of and the most practicable route for the construction of such a municipal railway. At the present time the Pacific Electric Company is endeavoring to obtain the franchise from Fifth street to Aliso, to relieve congested traffic on Main street.

PORTLAND, ORE.—One-half the Connell tract, containing ten acres, and bounded by East Twenty-second, Twenty-sixth, Powell and Frankfort streets, has been purchased by the Portland Railway, Light & Power Company, to be used as a site for a factory for the construction and repair of cars and the manufacture of other equipment for the railway lines of the company. President Josselyn of the power company has started East, where he will remain three weeks. When he returns it is believed that he will be prepared to announce the details of the big factory which it is said will be built next year.

TRANSMISSION.

SPOKANE, WASH.—Councilman Nelson is advocating a municipal power plant which is being considered by the city authorities.

LAKEVIEW, ORE.—The Southern Oregon Water Power Company, Fred H. Oliver, president, has made arrangements for installing a plant on Deep creek, 3 miles W. of Adel, to generate 10,000 horsepower.

BODIE, CAL.—Written tenders will be received by the Supervisors up to November 14th, for a 50-year franchise, applied for by the Hydroelectric Company, to erect and operate a transmission line for conducting electric current.

SEATTLE, WASH.—The first improvements to be undertaken by the Hanford Irrigation & Power Company will be the deepening of the main power canal for about a mile at Priest Rapids, to cost about $200,000; work to begin at once.

EUGENE, ORE.—The Eugene Heating & Power Company will resume work on the construction of the $7500 central heating plant. A contract had been previously signed by a Mr. Schafer, who after finishing about one-third of the work, left the city.

OROVILLE, CAL.—Stanward Logue has filed a claim upon 20,000 inches of water in the Middle Fork of the Feather river at a point 200 yards below the junction with the south branch of the Feather river. The water is to be used for purposes of power development.

RED BLUFF, CAL.—T. H. Ramsey, manager of the Cone ranch, has filed a notice of appropriation of water rights of 10,000 inches of the water in Mill creek. It will be delivered from the creek and carried in flumes to the Cone ranch, where it will be used for the generation of electric power.

SACRAMENTO, CAL.—A new wage agreement has been signed up by the Sacramento Valley Power Company, which grants the employes of that company a raise of 75c per day in wages and decreases the working hours from nine to eight per day. The contract provides for a closed shop, the company agreeing to hire all its electricians through the union.

TUCSON, ARIZ.—The Great Western Power Company is engaged in preparations for the construction of a reservoir and power project in the Sabino Canyon. A tunnel will also have to be constructed to divert the waters of the canyon to enable the construction of the dam. W. B. Alexander consulting engineer of the company, states that an expenditure of $1,000,000 to $1,500,000 is involved.

WATERWORKS.

ORANGE, CAL.—In the neighborhood of $1600 will be spent in water development in Santiago canyon by the Villa Park and El Modena water companies during the coming season.

REDLANDS, CAL.—The Domestic Water Company has taken the contract for laying more than 5000 feet of water mains in alleys back of lots and 109 lots will get water supply from this source. Pipe will be laid in a new tract called University subdivision.

TRUCKEE, CAL.—The Truckee Water & Light Company is setting up new posts and stringing heavier wires, preparatory to making a change in the power plant. The dynamo, which has been located one-half mile east of town, will be moved to town and installed so as to work in conjunction with the power house of the Truckee Lumber Company.

GEORGETOWN, CAL.—The Loon Lake Water & Power Company, successors to the old California Water and Mining Company, which has operated the water system on the Georgetown Divide for the last forty years, is making extensive preparations for the building of large storage reservoirs and the erection of hydroelectric power plants on this divide. This work will not be completed for several years.